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KINGZETT'S
CHEMICAL ENCYCLOPÆDIA

First Edition, December, 1919
Second Edition, April, 1922
Third Edition, May, 1924
Fourth Edition, February, 1928
Fifth Edition, May, 1932

9.6.32

40/- net

CHEMICAL ENCYCLOPÆDIA

A DIGEST OF CHEMISTRY AND ITS INDUSTRIAL APPLICATIONS

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BY

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"THE HISTORY, PRODUCTS, AND PROCESSES OF THE ALKALI TRADE" (LONGMANS);
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"NATURE'S HYGIENE AND SANITARY CHEMISTRY" (BAILLIÈRE, TINDALL AND COX);
"CHEMISTRY FOR BEGINNERS AND SCHOOL USE" (BAILLIÈRE, TINDALL AND COX)
ETC., ETC.

FIFTH EDITION

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PREFACE TO THE FIFTH EDITION

During a period approximating to five years I have devoted unremitting labour to the preparation of this new edition in order to keep pace with the rapid progress made in scientific knowledge affecting industry and the public weal, and to retain its character as a one-volume, compendious, comprehensive Encyclopædia of Chemistry and Industry. Many new subjects have been introduced, so that after meticulous revision, necessary amplification, and rigorous condensation, it now runs into upwards of 200 more pages than its predecessor, and it is up to date so far as such a work can be kept while going through the press.

Apart from its value to Manufacturers and all engaged in the study, practice, and applications of chemistry, and dealing, as it does, with so many subjects concerning the trade of the British Commonwealth and public health and wealth, it will, I hope, secure greater use by Politicians, Journalists, Teachers, Lawyers, Merchants, Brokers, Medical Practitioners, Pharmacists, Company Directors, and other sections of the professional and cultured classes.

The greatly augmented bibliographical references should also make it of increased service to those who may desire to obtain more extensive or specialist information relative to any of the multitudinous subjects with which it deals.

My thanks are sincerely tendered to all chemical friends and correspondents who have kindly given me help in my heavy task, particularly Professor G. T. Morgan, Professor H. T. S. Britton, and Dr. O. Rosenheim for information on special subjects, and Mr. H. F. Bottomley and Mr. J. E. Brimley (two of my old assistants) for valuable aid in checking the accuracy of a great number of the cited references.

C. T. KINGZETT.

" Newlands,"
Weybridge,
April 2nd, 1932.

EXTRACTS FROM
PREFACE TO THE THIRD EDITION

From the time of my student days I have been deeply impressed with the comparative neglect of chemical science and its teaching in this country, as also with the failure of Government departments and the public alike to appreciate the importance of that science as a factor in education and the inestimable value of the services that can be rendered to the State by its exponents.

It was this sense and the existence of certain abuses that then affected the chemical profession that largely induced me as a young man to take an active part in the creation of the Institute of Chemistry, of which I became one of the founders in the year 1876.

When the Great War came in 1914, and the Government looked to our chemists to make good its neglect of many years, in order to overtake the tremendous advancements made and utilized by the aggressor nation, Germany, I set myself two tasks, which, being performed, might help to popularize the study of chemistry and advance its applications to industry within the Empire.

There was already in existence an overwhelmingly large number of chemical textbooks, but none of them, in my view, fully met the want of a quite simple, readily understandable beginner's book for use by young boys and girls, and in schools of all classes; hence the production of my little work entitled *Chemistry for Beginners and School Use* (Baillière, Tindall and Cox), which includes a simple lexicon and is now in its fourth edition.

The other task was a more ambitious one, and, while it has been a labour of love, it has proved a somewhat exhaustive one—viz., the production of this Encyclopædia, which is unique in character and now makes its appearance in the third edition under a new title. My aim has been to prepare an epitomized digest of chemistry and its industrial applications, in a form which should be useful as a work of reference by all classes of the community.

* * * * *

As emphasized in the earlier issues, the future welfare of our Empire depends, in the main, upon increased production within its boundaries by the utilization of its boundless natural resources, and to attain success, reliance must be placed upon the increased teaching and application of chemical science; if we fail in this, we must inevitably fall behind competing nations.

As to the more scientific aspects of the work, it may be permissible to add that, while appreciating the great advances made in recent years concerning atomic structure, we must not be led thereby to think that chemistry is in any state of flux, for most assuredly that is not so. Whereas chemists were wont to talk and write about matter and force, there have been substituted the terms nuclear protons and electrons; they are much the same things, and chemistry remains what it was and always will be—viz., the study of the laws of changes of matter.

The chemical elements, their allotropic and isotopic forms, and the myriads of chemical compounds with their varying modifications, are so many chemical entities, resolvable by force into infinite further varieties; and in all probability the ninety-two atomic structures or so-called elements now recognized are but modified forms of one simple unit matter. This view—even then an old one—to which I expressed adhesion in almost my earliest printed communication of a chemical character, entitled the *Oneness of Matter* (now more than fifty years ago), has since seized the imagination of, and is now probably entertained by, most chemists and physicists.

C. T. KINGZETT.

" NEWLANDS,"
WEYBRIDGE,
March, 1924.

EXPLANATORY NOTES

Atomic Weights.—The atomic weights given in the respective descriptions of the elements are those listed in a table (printed on pp. 303-304) issued by a Committee of the Chemical Society in the January, 1929, number of that Society's journal.

Temperatures.—Unless otherwise expressed, all temperatures are to be understood as in terms of the Centigrade system.

Abbreviations.—

Acet. v.	means	acetyl value.
acid v.	,,	acid value.
atm.	,,	atmospheres (pressure units).
A.U.	,,	Angström Unit.
Bé.	,,	Baumé.
b.p.	,,	boiling point.
B.Th.U.	,,	British Thermal Units.
cals.	,,	calories.
d.	,,	density.
d.	,,	dextro-rotatory.
f.p. or fr. p.	,,	freezing point.
grm. or gm.	,,	gramme.
i.v.	,,	iodine value.
l.	,,	lævo-rotatory.
m.p.	,,	melting point.
N.O.	,,	Natural Order.
opt. rot.	,,	optical rotation.
ref. ind.	,,	refractive index.
r.p.	,,	rotatory power.
sap. v.	,,	saponification value.
sp. gr.	,,	specific gravity.
Tw.	,,	Twaddell.
o- or 1 : 2	,,	ortho.
m- or 1 : 3	,,	meta.
p- or 1 : 4	,,	para.

Note.—For others see Electricity, pp. 297-298; Force, p. 369; Formulæ; Symbols; Weights and Measures, pp. 981-983.

B.C.A.: British Chemical Abstracts: A, *of the Chemical Society;* B, *Society of Chemical Industry.*
B.E.S.A.: British Engineering Standards Association (now "Brit. Standards Inst." B.E.S.).
Biochem. J.: Biochemical Journal (Cambridge University Press).
Brit. Med. J.: British Medical Journal.
Brit. Pharm.
B.P. } British Pharmacopœia.
C. and D.: Chemist and Druggist.
Chem. Age: Chemical Age.
Chem. and Ind.: Chemistry and Industry (*Journal Society of Chemical Industry*).
Chem. News: Chemical News.
Chem. Review: A quarterly publication of the American Chemical Society.
C.T.J.: Chemical Trade Journal.
Ind. Chem.: The Industrial Chemist.
Ind. Eng. Chem.: Journal Industrial and Engineering Chemistry.
J. Amer. C. S.: Journal of the American Chemical Society.
J. Biol Chem.: Journal Biological Chemistry.
J.C.S.: Journal of Chemical Society.
J.C.S. Abs.: Journal of Chemical Society Abstracts.
J. Inst. Chem.: Institute of Chemistry Journal.
J.S.C.I.: Journ. Soc. Chemical Industry.
Pharm. Journ.
Pharm. J. } *Pharmaceutical Journal.*
Trans. Inst. Chem. Eng.: Transactions, Institute of Chemical Engineers.

Proprietary Items.—These names are all expressed in inverted commas.

Crystal Systems.—References to crystal systems are to be interpreted by the classification given on p. 253.

CHEMICAL ENCYCLOPÆDIA

ABIETIC ACID ($C_{20}H_{30}O_2$)—A constituent of common rosin (colophony) which crystallizes in small plates, is of acid v. 183·7, and soluble in hot alcohol, ether, strong acetic acid, and chloroform. G. Rouin describes it as a hydrate $4C_{20}H_{30}O_2,H_2O$ of m.p. 171° to 173° C. (*B.C.A.*, 1929, 811). It can be obtained in a 50 per cent. yield by distillation of the rosin at 200° to 210° C. 1 mm. (bath 255° C.), followed by crystallization from methyl alcohol or acetone. So-called pimaric acid obtained from galipot (French rosin), m.p. 161° C., would appear to be identical with abietic acid. According to Dupont and Desalbres, well-defined abietates of various metals have been obtained in alcoholic solutions, alkali metals giving crystalline salts corresponding to a formula of $3C_{20}H_{30}O_2,C_{20}H_{29}O_2.M$. Potassium abietate is now produced commercially as a reddish-brown viscous paste soluble in cold water for use in place of rosin-soaps, etc.

The crystalline anhydride prepared by dehydration with acetic anhydride is said to have a m.p. of 151° C. (See C. Dupont and L. Desalbres, *B.C.A.*, 1926, A, 611, and Levy (with others), *Ibid.*, 1929, A, 1448; Gums and Resins.)

ABDERHALDEN (Electrically Heated Drier)—See Drying.

"ABOL"—A proprietary insecticide and fungicide, described as non-poisonous, for the destruction of insect and fungoid pests on plants, vegetables, etc.

"ABRAC"—A glycerine resin ester, of m.p. about 100° C., and not exceeding 5 acidity—that is, the number of milligrammes potassium hydroxide required to neutralize 1 gramme of gum. It is pale in colour, and has an ash content less than 0·1 per cent. (See Gums and Resins.)

ABRASIVES—Preparations such as "Aloxite," "Alundum" (crystallized aluminium oxide), "carborundum" (silicon carbide), "corubin," corundum, emery, garnet, lime, rouge, kieselgühr, pumice powder, sandstone, "sira," tripoli, oilstone, and whetstone, used for cleaning or abrading by rubbing. Black oxide of iron is stated to be the principal ingredient of the article called "Glassite," and aluminium oxide that of the preparation known as "Diamantine."

Hydrated magnesium silicates of the serpentine type, containing 3·5 per cent. iron, when calcined at a red heat and subsequently ground, are stated to produce useful abrasives.

Diamond-crushed steel, prepared from white-hot crucible steel and crushed cast iron by quenching, is used as an abrasive for cutting granite, marble, and glass.

Emery, a native hard form of alumina coloured with oxides of iron

ABRASIVES (*Continued*)—

and manganese, in the raw state comes from the Island of Naxos, in the Greek Archipelago (see Corundum); silicon carbide, corundum, and corundite are found in South Africa; and an aluminous abrasive is found in the south of France and the Pyrenees. All are used in making grinding-wheels, polishing, etc.

"Carborundum" and "Alundum" (electric furnace products) are the two chief abrasives. "Alundum" is a form of aluminium oxide (Al_2O_3) made by fusing bauxite in the electric furnace; m.p. approximately 1,750° to 2,100° C., and sp. gr. about 4·0. "Aloxite" is another form of the same substance prepared by fusion of bauxite.

"Carborundum" (SiC) is a greenish blue-black crystalline silicon carbide of sp. gr. 3·12-3·20 largely used by reason of its great hardness (ranking in this character next to the diamond) for grinding and cutting metals in engineering shops. It is made of various degrees of purity up to 99·5 per cent. and graded between 20 and 100 mesh screens, by heating a mixture of silica, fine sand, and finely ground petroleum coke with a little salt and sawdust in an electric furnace, using a current of 10,000 ampères. In this way a ring of crystals is built up surrounding the core, the annual production being estimated at 30,000 tons.

N.B.—The name "Carborundum" is the registered trade mark of the make of silicon carbide of the Carborundum Company of Niagara Falls, in Canada, Australia, New Zealand, and the U.S.A., but the name is not registered in Great Britain.

In the electroplating industry, rottenstone, tripoli, pumice, and emery are the more important abrasives employed.

See account of the manufacture of carborundum and aloxite as conducted by the Carborundum Co., Ltd., at Manchester, (*Ind. Chem.*, 1930, vi., 321); also L. Wright (*Chem. and Ind.*, 1928, **47**, 1154), and F. L. Nobes (*Ind. Chem.*, 1930, vi., 183).

ABSINTHE—A bitter and drink, used in France and Switzerland, prepared from various species of "Artemesia," of which the *A. glacialis* and *A. mutellina* are used in making absinthe. The unexpanded flower-heads of another variety (*Artemesia maritima*) constitute the source of santonin. A substance named absinthin ($C_{40}H_{56}O_8 \cdot H_2O$) is said to be the bitter principle of the common wormwood (*A. absinthium*), and is a crystalline body, slightly soluble in water and readily soluble in alcohol. (See Wormwood.)

ABSORPTION—The physical soaking up of one substance into another; distinct from adsorption. (See I. C. Philip, *Ind. Chem.*, 1929, v., 534.)

ABSORPTIOMETER—Apparatus for determining solubilities of gases.

ABSORPTION BULBS—See Organic Analyses.

ABSORPTION TOWERS—See Tower Fillings.

Ac—A prefix sometimes used for acetyl (CH_3CO).

ACACIA—A genus of leguminous trees, of which there are a great number of species of the sub-order Mimoseæ. (See Gums.)

ACANTHITE—Natural silver sulphide (Ag_2S), of sp. gr. 7·25 and crystal system No. 1, containing 87 per cent. silver, found in Colorado.

ACCROIDES GUM—See Gums and Resins.

ACCUMULATORS (Storage Batteries)—See Electricity, p. 296.

ACENAPHTHENE ($C_{10}H_6(CH_2)_2$)—An intermediate dyestuff found in coal tar, being a white crystalline body of m.p. at 95° C. and b.p. 277° C.; soluble in alcohol, and yields naphthalic acid on oxidation. Some of its derivatives are suitable for the production of intermediates utilizable in making dyes and therapeutic compounds. The nitration, sulphonation, and halogenation of this body takes place most readily in the *para* positions with respect to the two methylene groups. (See Morgan and Harrison, *J.S.C.I.*, 1930, **49,** 414 T, and British Patent Specification 305,754 of 1927 of G. T. Morgan with others.)

ACER-TANNIN—A substance extracted by the Japanese from the leaves of *Acer ginnala*. It will not tan leather, but yields a good dye. (See Tannins, p. 893.)

ACETAL ($CH_3.CH(OC_2H_5)_2$)—A colourless, volatile solvent liquid of sp. gr. 0·831, b.p. 104° C.; made by partial oxidation of ethyl alcohol; soluble in water, alcohol, and ether.

ACETALDEHYDE—See Aldehydes.

ACETALS—Compounds resulting from the combination of two alcohol molecules with one of an aldehyde or ketone—the dialkyl ethers of hypothetical glycols.

ACETAMIDE—See Amides.

ACETANILIDE (Phenylacetamide) (C_8H_9NO) or ($C_6H_5.NH.CO.CH_3$)—A white crystalline intermediate known under the common name of "Antifebrine," and used as a medicine in fever cases. It is readily soluble in hot water, alcohol, ether, and chloroform, and is made by boiling aniline with glacial acetic acid. M.p. 113° C.

ACETATES—See C. H. Butcher on "The Acetates in Industry" (*C.T.J.*, 1931, **89,** 151 and 179) and Acetic Acid.

"ACETEX"—A variety of safety glass.

ACETIC ACID ($C_2H_4O_2$)—The active principle of vinegar, which contains from 3 to 5 per cent. It is readily prepared by the oxidation of ordinary alcohol and the fermentation of alcoholic liquids by a minute organism (*Mycoderma aceti*). It is also extracted from the products of the dry distillation of wood. The greater part of the commercial acid is prepared from this source; the acid is converted into calcium acetate by treatment with lime, and the resulting calcium acetate subsequently dissociated by treating it with hydrochloric acid, the free acetic acid being finally obtained by distillation. Or it is made from the crude calcium acetate by treatment with sulphuric acid of 66 per cent. strength, which gives a liquor of 75 per cent. strength acetic acid, and this by fractional distillation yields first of all dilute acetic acid and then the glacial acid.

By one process it is extracted direct from the crude pyroligneous

ACETIC ACID (*Continued*)—

liquor by means of ether; in another, ethyl acetate is used, while the "Suida" process employs a high boiling wood oil, the acetic acid being recovered from the oil by vacuum distillation. (See *C.T.J.*, 1929, **85**, 541.)

Pure acetic acid (glacial acetic acid) is a corrosive crystalline body of sp. gr. 1·055 at 15° C., m.p. 16·7° C., b.p. 118° C., soluble in water and alcohol.

What is known as the "quick process" of producing ordinary acetic acid consists in trickling dilute alcoholic liquors over shavings of beechwood previously coated with "mother of vinegar"—that is, a cultivation of the *Mycoderma aceti*—at a temperature of 35° C. The souring of thin wines is due to the production of acetic acid by the same micro-organisms, which are always present in the air. (See Vinegar.)

A process for the production of acetic acid from acetylene is as follows: calcium carbide is prepared by heating lime with coke in an electric furnace, and the acetylene produced from this product is then combined with water, through the agency of sulphuric acid acting in conjunction with mercuric and ferric sulphates, whilst the resulting acetaldehyde is oxidized by oxygen distilled from liquefied air. (See *C.T.J.*, 1927, **80**, 553.)

It can also be made commercially by a fermentation process from the sugar resulting from acidic hydrolysis of sawdust together with lactic acid. (See *C.T.J.*, 1929, **85**, 300.)

Acetic acid in its various forms finds large application as a food preservative and flavouring material, also in many industrial processes, including the manufacture of cellulose acetate, white-lead, and the treatment of rubber latex. For technical purposes it is put on the market in liquid forms containing respectively 40, 60, and 80 per cent., etc.

By combination with bases, acetic acid forms the salts known as acetates, most of which, including all the normal ones, are soluble in water. (See Pyroligneous Acid, and Vinegar.)

ACETIC ANHYDRIDE ($C_4H_6O_3$ or $(CH_3.CO)_2O$)—A colourless mobile liquid of sp. gr. 1·073 at 20° C. and suffocating odour, which boils at 137° C. It can be obtained by distilling acetyl chloride with an alkali acetate, but is mainly made by the action of sulphur chloride on anhydrous sodium acetate, and may be chemically regarded as derived from acetic acid by the abstraction of a molecule of water from two molecules of the acid—$2C_2H_4O_2 - H_2O = C_4H_6O_3$. A description of the "Hausler-McLang" process is given in the *C.T.J.*, 1925, **76**, 787, and its manufacture by the "Beatty-McLang" process (also claimed by Eug. Terlinck), *Ibid.*, June 11 and 2 6,1926, and 1927, **80**, 106; see also E. Fritzman, *B.C.A.*, 1929, B, 1007. It is used in making aeroplane dope, is soluble in alcohol and ether, and resolved by water into acetic acid.

ACETIC ETHER—See Ethyl Acetate under Esters.

ACETIN (**Monoacetin**) ($C_2H_3O_2.C_3H_5(OH)_2$)—A colourless, thick liquid of sp. gr. 1·2212, prepared by heating glycerol and glacial acetic acid; soluble in water, alcohol, and ether; used for gelatinizing smokeless gunpowder and dynamite, and as a solvent for slightly soluble dyestuffs, particularly induline base. (See Glycerol and Triacetin.)

"ACETOL"—A liquid fuel made in Rhodesia from molasses, containing 80 per cent. alcohol and 20 per cent. other ingredients, including acetylene; useful for internal combustion engines.

ACETONE (**Di-methyl ketone**) (C_3H_6O or $(CH_3)_2 : C : O$)—A mobile, inflammable, colourless liquid of agreeable characteristic odour, obtained, amongst other methods, by the dry distillation of calcium acetate in a stream of inert gas (nitrogen or carbon dioxide) at 450° to 490° C., the yield being reported as almost quantitative under carefully observed conditions. It can also be prepared from sodium acetate in association with grey lime, and it is made in the U.S.A. from *iso*propyl alcohol derived from propylene from natural or cracked petroleum gas.

To produce acetone from glacial acetic acid, the latter is vaporized and passed through a heated vessel or steel tubes containing a catalyst which effects its decomposition, as expressed by $2CH_3COOH = (CH_3)_2CO + CO_2 + H_2O$. A yield of up to 95 per cent. is obtained by passing the preheated vapour over granulated calcium oxide mixed with a small amount of magnesia at 483° C. The resultant vapours from the tubes are scrubbed in a soda-tower to remove any unchanged acetic acid and the acetone is subsequently rectified by distillation. For recovering acetone vapour from the air by scrubbing operations, strong sulphuric and phosphoric acids are stated to effect almost perfect absorption. (See W. R. Ormandy, *B.C.A.*, 1930, B, 49.)

There are also biochemical (bacterial) processes for the production of acetone in association with butyl alcohol (in the proportions of one and two respectively, attended by evolution of carbon dioxide and hydrogen) from a starchy mass under aseptic conditions, maize being the material chiefly used during the war. In Weizmann's process the particular species of bacillus employed is known as "BY." (See A. C. Thaysen (*Chem. and Ind.*, 1926, **45,** 71; *C.T.J.*, 1927, **80,** 83; C. L. Gabriel, 1929, **85,** 238); W. G. Cass (*Ind. Chem.*, 1926, ii., 209); Lecture by J. V. Eyre (*Inst. Chem.*, November, 1931) on Fermentation Industries, p. 19; and Fermentations.)

It is miscible with many other commercial solvents, and is largely used in the manufacture of explosives, butadiene, and chloroform, also as a solvent of gun-cotton, celluloid, and wood-tar bodies; it boils at 56° C., and has a sp. gr. of 0·81 at 0° C. Chemically, it belongs to a series of "ketones," and it is said to be present in urine in small quantity. (For other details of its properties see *J. Amer. Chem. Soc.*, November, 1926; see also Acetic Acid and Ketones.)

ACETOPHENONE ($C_6H_5.CO.CH_3$)—A white, crystalline body, m.p. 20·5° C., made from benzene by treatment with acetyl chloride in presence of aluminium chloride; soluble in alcohol and ether, and used in perfumery.

ACETYL (CH_3CO—)—An organic radical derived from acetic acid.

ACETYL CHLORIDE (C_2H_3ClO)—A colourless mobile liquid which boils at 55° C., and has a suffocating odour.

ACETYL CHOLINE—A body represented as having the constitutional formula ($(CH_3)_3N(OH)CH_2.CH_2.O.CO.CH_3$) and released around the heart cells by excitation of the vagus; said to be possessed of a physiological action 1,000 times greater than that of choline. (See A. J. Clark, *Chem. and Ind.*, 1930, **49**, 533.)

ACETYL SALICYLIC ACID—See Aspirin.

ACETYL VALUES—See Fats.

ACETYLENE BLACK—Made by burning acetylene against a cooled metal surface, as also by several chemical processes; is inferior to the carbon made by burning natural gas. Acetylene black is reported as chemically purer than gas black and lamp black, and a comparison of the three has been made by T. R. Dawson (*B.C.A.*, 1931, B, 6).

ACETYLENE (**Ethine**) (C_2H_2)—A poisonous hydrocarbon gas of sp. gr. 0·91 produced from calcium carbide by action of water—($CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$). Its production by cracking of methane is subject of a paper by Frolich and others (*B.C.A.*, 1930, B, 173). The "Aceta" plant, with a carbide capacity of 4 cwts., is said to generate a continuous output of 500 cubic feet of pure acetylene per hour. It can be liquefied at 1° C. under a pressure of 48 atmospheres; is soluble in water, alcohol, and acetone, and used as an illuminant. By burning it in conjunction with oxygen in blow-pipe form, a very high temperature is attained—higher, indeed, than that of the oxyhydrogen flame —and used as a means for cutting through armour-plates up to 6 inches in thickness even when under water. Just above the top of the luminous cone the temperature has been determined as about 3,100° C. (Henning and Tingwaldt, *B.C.A.*, 1928, A, 826). So-called "dissolved acetylene" is acetylene compressed into a cylinder containing a suitable porous material soaked in acetone, a solvent which absorbs a large quantity of acetylene under pressure and gives off the gas freely when the pressure is released, thus qualifying it to be safely transported and used in the same way as oxygen.

The reactivity of acetylene renders it very useful in many chemical syntheses, and when it can be produced cheap enough it is likely to find great employment in the manufacture of acetic acid, alcohol, acetal, aldol, and other compounds. It is used in the preparation of a number of solvents. There are processes for using it in the manufacture of oxalic acid and chloral, and it is stated to be finding favour as an anæsthetic. (See Narcylene.) Acetylene in contact with copper forms copper acetylide, a compound which readily detonates upon friction. (See D. Binnie on "The Formation of Oil from Dilute Acetylene" (*J.S.C.I.*, 1931, **50**, 297 T); R. Spence on "The Slow Combustion of Acetylene" (*J.C.S.*, 1932, p. 686); Alcohol (Ethyl), Oxy-acetylene Flame, Solvents, and Welding.)

ACETYLENE TETRACHLORIDE ($CHCl_2.CHCl_2$).—See Tetrachlorethane.

ACETYLIZATION (Acetylation)—The introduction of the acetyl radical (CH_3CO—) into compounds, such as alcohols, phenols and amines, by boiling with acetic anhydride or acetyl chloride, etc.

ACICULAR (Crystals)—Needle-shaped.

ACID, CLEVES (Acid Alpha-Naphthol sulphonic, 1 : 5)—An intermediate.

ACID EGGS—See Data Sheets.

ACID F (Acid Beta-Naphthylamine monosulphonic, 2 : 6) ($C_{10}H_6(NH_2)SO_3H$)—An intermediate.

ACID FREUND'S (Naphthylamine disulphonic Acid, 3 : 6) ($C_{10}H_5(NH_2)(SO_3H)_2$)—An intermediate.

ACID G (Acid Amino-Naphthol-sulphonic, 2 : 8 : 6) ($C_{10}H_5(OH)(NH_2)SO_3H$)—An intermediate.

ACID H (Acid Aminonaphtholdisulphonic, 1 : 3 : 6 : 8) ($C_{10}H_4(OH)(NH_2)(SO_3H)_2$)—An intermediate, the manufacture of which is described in an article in the *Ind. Chem.*, 1925, i., 141.

ACID J (2-Amino-5-Hydroxy-Naphthalene-7-sulphonic Acid)—An intermediate.

ACID K (1-Amino-8-Naphthol-4:6-disulphonic Acid)—An intermediate.

ACID, KOCH (Alpha-Naphthalene trisulphonic Acid, 3 : 6 : 8) ($C_{10}H_4(NH_2)(SO_3H)_3$)—An intermediate.

ACID, LAURENT'S (Nitro-Naphthalene-sulphonic, 1 : 5) [$C_{10}H_6(NO_2)(SO_3H)$.]—An intermediate, being a pale yellow crystalline body, soluble in water, alcohol, and ether.

ACID, NAPHTHIONIC (Alpha-Naphthylamine-sulphonic, 1 : 4) ($C_{10}H_6(NH_2)(SO_3H)$—An intermediate.

ACID, NEVILLE and WINTHER (Alpha-Naphthol-sulphonic, 1 : 4) [$C_{10}H_6(OH)(SO_3H)$]—An intermediate.

ACID PUMPS—See Pumps.

ACID RESISTANCE—With respect to the use of materials in construction of chemical plant and buildings, see W. H. Hatfield on "The Fabrication of Acid-resisting Steel Plant" (*Chem. and Ind.*, 1929, **48**, 1061; *Chem. Age*, xv., 198); McMyn and Edge on "Acid-resisting Metals" (*Chem. and Ind.*, 1931, **50**, 474); also Bricks, Cements, Chemical Plant, Corrosion, Iron, and Refractories.

ACID, SULPHANILIC (1 :3) ($C_6H_4(NH_2)SO_3H$—An intermediate.

ACIDIC—In a modern view of electrons, acids are bodies which can part with a proton to bases.

ACIDIMETRY—The determination of amount of acid in a solution by titration with a standard alkali solution. (See Volumetric Analyses.)

"ACIDOL"—A pharmaceutical preparation of betaine hydrochloride, a colourless crystalline substance which upon solution in water hydrolyses, yielding hydrochloric acid. It is used therapeutically, and is a potential source of various methyl amines. (See Betaïne.)

ACIDS—By the word "acids" is meant, in a general sense, liquids that are sour, but chemically as solutions of substances which undergo ionization by electrolytic dissociation forming hydrogen ions.

There are a great number of acids, derived from various sources, all of which may be regarded as hydrogen salts, in which the ionogenic hydrogen is replacable by metals or basic groups. The strength of an acid is its degree of ionization, and that determines the rate at which a metal can replace hydrogen. Acids turn vegetable blue colours into red colours, tincture of litmus being ordinarily employed for such testings. (See Acidic and Volumetric Analyses.)

Hydrochloric Acid (HCl), **Nitric Acid** (HNO_3), and **Sulphuric Acid** (H_2SO_4) are the three best-known inorganic acids, and are all largely used in commerce and manufacturing operations.

Citric Acid (the acid of citrons and lemons), **Acetic Acid, Malic Acid** (the acid of apples), **Tartaric Acid,** and **Oxalic Acid,** are five of the better-known acids from organic sources.

These several acids—all of which are soluble in water—by combination with bases form the corresponding chlorides, nitrates, sulphates, citrates, acetates, malates, tartrates, oxalates, etc., as illustrated by the following typical equations:

$$\underset{\text{(Hydrochloric Acid)}}{2HCl} + \underset{\text{(Sodium Oxide)}}{Na_2O} = \underset{\text{(Sodium Chloride)}}{2NaCl} + \underset{\text{(Water)}}{H_2O}.$$

$$\underset{\text{(Nitric Acid)}}{HNO_3} + \underset{\text{(Sodium Hydroxide)}}{NaHO} = \underset{\text{(Sodium Nitrate)}}{NaNO_3} + \underset{\text{(Water)}}{H_2O}.$$

$$\underset{\substack{\text{(Sulphuric}\\ \text{Acid)}}}{H_2SO_4} + \underset{\substack{\text{(Sodium}\\ \text{Carbonate)}}}{Na_2CO_3} = \underset{\substack{\text{(Sodium}\\ \text{Sulphate)}}}{Na_2SO_4} + \underset{\text{(Water)}}{H_2O} + \underset{\substack{\text{(Carbon}\\ \text{Dioxide)}}}{CO_2}.$$

These acids and many of their compounds are described under their several names.

Acids are termed monobasic, dibasic, tribasic, and tetrabasic, according to the number of hydrogen atoms contained in them replaceable by a metal; thus, acetic acid is monobasic, sulphuric acid is dibasic, and so forth.

Organic Acids, like the inorganic series, may be generally described as substances capable of yielding salts by interaction with metallic or other bases. They are of immense numbers and diverse characters. One series corresponds to the primary alcohols and aldehydes described under these several headings, and is known as the acetic or "fatty acids" series, thus—

Formic acid (CH_2O_2) corresponds with Methyl alcohol (CH_3HO);
Acetic acid ($C_2H_4O_2$) with Ethyl alcohol (C_2H_5HO);
Propionic acid ($C_3H_6O_2$) with Propyl alcohol (C_3H_7HO);
Butyric acid ($C_4H_8O_2$) with Butyl alcohol (C_4H_9HO);
Valeric acid ($C_5H_{10}O_2$) with Amyl alcohol ($C_5H_{11}HO$);
Caproic acid ($C_6H_{12}O_2$) with Hexyl alcohol ($C_6H_{13}HO$).
And so on.

ACIDS (*Continued*)—

It will be seen that these acids rise in steps of CH_2, and they are formed by the oxidation of their corresponding alcohols or aldehydes. Many of the higher members of the series are solid bodies, including lauric, myristic, palmitic, cerotic, and melissic acids among the better-known ones. (See Morgan and Holmes on the X-ray measurements of some of the higher fatty acids, *J.S.C.I.*, 1928, **47**, 309 T.)

Another group of organic acids is the so-called lactic acid (monobasic) series; a third group is known as the oxalic acid (dibasic) series, and yet another group (styled the aromatic acids) analogous to the fatty acids. Many of the individual members of these various groups are described under their respective names.

The chemical relationships between the members of the lactic and oxalic series of acids respectively are shown by the following typical examples:

Carbonic Acid $\left.\begin{matrix}CO\\H_2\end{matrix}\right\}O_2$	Oxalic Acid $\left.\begin{matrix}C_2O_2\\H_2\end{matrix}\right\}O_2$
Glycolic Acid $\left.\begin{matrix}C_2H_2O\\H_2\end{matrix}\right\}O_2$	Malonic Acid $\left.\begin{matrix}C_3H_2O_2\\H_2\end{matrix}\right\}O_2$
Lactic Acid $\left.\begin{matrix}C_3H_4O\\H_2\end{matrix}\right\}O_2$	Succinic Acid $\left.\begin{matrix}C_4H_4O_2\\H_2\end{matrix}\right\}O_2$

The phenols and cresols, or so-called tar acids, while having weak acid-like characters, stand in a class by themselves and to some extent behave like alcohols.

Hydrocyanic acid (HCN) (a member of the cyanogen group of compounds) constitutionally resembles hydrochloric acid, the radical cyanogen (CN) behaving like chlorine in this respect and playing a corresponding part in many of its compounds.

Certain fatty acids can be obtained by the catalytic oxidation of petroleums and paraffin wax. (See Fats and Petroleum.)

"ACIDSTONE" (**Guthrie Composition**)—A material used in making unbreakable, non-absorbent, corrosion-proof plant offering a considerable resistance to heat.

ACONITIC ACID ($C_6H_6O_6$ or $COOH.CH:C(CO_2H).CH_2.COOH$)—A crystalline substance of m.p. 172° to 173° C., soluble in water, occurring naturally in the root of *Aconitum napellus* (a perennial herb found in the lower mountain slopes of Central Europe and cultivated in England), shave-grass, and cane-juice. It is tribasic and can be prepared by heating citric acid ($C_6H_8O_7$), which causes the loss of the elements of water. It is stated to occur in two geometrical isomeric forms, the ordinary form m.p. 194° to 195° C. being the more stable, and the other form m.p. 125° C. (See Malachovski and Maslovski, *B.C.A.*, 1929, A. 172.)

ACONITINE ($C_{34}H_{47}NO_{11}$)—A white, crystalline, extremely poisonous alkaloid of m.p. 204° C. obtained from aconite root; soluble in alcohol and ether. The leaves of *Aconitum napellus* (Monk's-hood) contain

ACONITINE (*Continued*)—
from 0·1 to 1 per cent. of the alkaloid (associated with several others, including neopelline $[C_{28}H_{33}O_5[OMe]_3 : NMe,3H_2O])$, which is used medicinally in admixture with chloroform in the form of a liniment, to relieve neuralgia, etc. Some Indian aconites contain an alkaloid named pseudaconitine ($C_{34}H_{47}$ NO_{10}), m.p. 132° to 135° C. (See T. M. Sharp, *J.C.S.*, 1928, p. 3094.)

ACRIDINE ($C_{13}H_9N$)—A basic constituent of the heavy tar oils as produced in high-temperature carbonization of coal. It is a colourless crystalline body of intensely irritating character, and is chemically related to anthracene. The acridine dyestuffs have the chromogene acridine ring. (See Tar.)

ACRIFLAVIN—A dye used as an antiseptic and curative agent in cases of sleepy sickness.

ACROLEIN (C_3H_4O or $CH_2 : CH.CHO$)—A substance of aldehydic character produced by the oxidation of allyl alcohol (C_3H_6O), and by the destructive decomposition of fats by heat. It is a colourless, inflammable, and poisonous liquid of extremely pungent odour, having a violent action on the eyes. Sp. gr. 0·84; b.p. 52° C.; soluble in water, alcohol and ether. It yields acrylic acid ($C_3H_4O_2$) by oxidation, and this, upon fusion with alkali, breaks up into acetic and formic acids. (See Zappi and Labriola, *Analyst*, 1932, **57**, 59.)

"ACROLITE"—A synthetic resin made by condensation from glycerol and phenol. (See *Ind. Chem.*, 1927, iii., 80.)

ACRYLIC ACID—See Acrolein.

"ACTICARBONE"—See Carbon.

ACTINISM—The chemical effects of light, chiefly exercised by the violet rays. (See Photo-catalysis, Photo-chemistry, and Radio-activity.)

ACTINIUM (Ac)—Name of a radio-active substance now described as an element having the atomic number 89, resembling and being probably a product of the disintegration of uranium; said to be the shortest-lived substance, having a life-period of one five-hundredth part of a second. It is obtained from uranium minerals (pitch-blende), and has been described as a degenerated product of proto-actinium (with a probable atomic weight of 231).

ACTINOMETERS—Instruments for measuring photo-chemical intensity of light, as exhibited by exposure of chemical substances thereto.

"ACTOL"—Silver lactate, said to have considerable disinfectant properties.

"ACULMITE"—An American non-ferrous alloy for chemical plant, stated to be very resistant to acids, fruit juices, etc.

ACYCLIC—A term descriptive of open-chain carbon compounds like the olefines and paraffins. (See Cylic.)

ACYL RADICALS—The radicals left after removal of OH from organic acids—for example, $CH_3.CO$ (acetyl), $C_2H_5.CO$ (propionyl) derived respectively from acetic and propionic acids.

"ADAMANTINE"—A proprietary brand of blue firebricks and blocks described as fire and alkali-proof for use in construction of sulphur, pyrites, zinc-blende, and other burners.

"ADCO"—Name of proprietary reagents, described as bacterial stimulants in respect of the organisms that decompose cellulose; containing nitrogen in a form suitable for the elaboration of protein; used for converting garden refuse, etc., into farmyard manure.

"ADCOL N.P."—A make of specially refined lubricating oil.

ADDITIVE COMPOUNDS—Are those formed, as it were, by mere addition of elements to compounds or by molecular combination instead of by substitution or replacement. For example, ethylene (C_2H_4), an unsaturated hydrocarbon, combines with chlorine, forming ethylene chloride ($C_2H_4Cl_2$), by direct addition, thus satisfying two spare affinities of the carbon atoms in the ethylene.

An additive reaction is one in which two or more molecules react to yield one product; similarly the direct combination of sulphur and oxygen forming sulphur dioxide is an additive reaction.

ADENINE ($C_5H_5N_5$)—An alkaloidal or nuclein base found in the pancreas and in a number of vegetable growths including lucerne, resulting from the hydrolysis of a nucleo-protein; also produced synthetically. (See Nucleins.)

ADEPS LANÆ (**"Lanoline"**)—A refined wool fat of m.p. about 40° C., containing cholesterol and about 30 per cent. water, prepared from "suint." From investigations made at the National Physical Laboratory at Teddington, "lanoline" brushed on or deposited from a solution would appear to be the best coating as a preservative for the bright steel parts of stored machinery; solvent naphtha and white spirit proving the best carriers. (See Special Report No. 12 of the Engineering Research Board, H.M. Stationery Office.) It is also used for super-fatting toilet soaps and in preparing ointments and cosmetics, etc. (See Wool.)

ADHESION—The property of holding particles together.

ADHESIVES—Some varieties are made from the proteins or alkali-proteins which are isolated from the residues resulting from the extraction or expression of oils from seeds, and in particular hemp-seed and castor-beans. These are treated with suitable bases, such as the alkaline-earth hydroxides or magnesia, and with an alkali salt (such as sodium fluoride or arsenate), which will react slowly with the bases and form alkali hydroxide, the resulting product being then mixed with dilute alkali hydroxide solution.

Among other proteins the casein precipitated from skimmed milk by the action of rennet or acids is used, being passed through a 60-mesh

ADHESIVES (*Continued*)—

sieve after washing and drying. A cement having good keeping and adhesive characters, used in aeronautical construction, is made from the formula:

Casein	78·0 per cent.
Sodium carbonate	4·5 ,,
Sodium fluoride	4·0 ,,
Freshly slaked lime	12·5 ,,
Sodium arsenate	1·0 ,,

the ingredients being ground to pass through a 90-mesh sieve. Another useful cement is also prepared from glycerine and litharge.

Casein cements possess certain advantages over gelatin glues, as they keep well, are easily rendered fluid, can be used cold, and are inodorous. A cold adhesive of excellent quality is stated to be made by mixing 100 parts of an organic colloid such as casein with 10 parts alum and 3 to 5 parts of soda-ash, the whole being subsequently well mixed with 500 parts water.

Sodium silicate in solution is largely used as an adhesive, being fire-resisting and repellent to vermin, and a good account of its qualities and applications is given by R. Furness (*Ind. Chem.*, i., 197).

Adhesives are also made from seaweeds, various starches, flax residue, blood albumin, rubber, citrus fruits, and gelatinous bodies such as Iceland moss, isinglass, gums, and glues, as also from the sulphite wash liquors resulting from paper-making. The adhesive power of good gelatin is much greater than that of commercial glue, using equal concentrations of the two substances.

Adhesives are used in the manufacture of plastic materials, distempers, ply-wood, briquettes, and many other industries.

Adhesive action is the subject of articles by J. W. McBain and D. G. Hopkins (*J. Phys. Chem.*, 1925, **29,** 188-204; see McBain and Hopkins, *B.C.A.*, 1925, B, 292), and McBain and Lee (*J.S.C.I.*, 1927, **46,** 321 T); The strength of thin films, by the same authors (*J. Phys. Chem.*, 1926, **30,** 114-125 (abstract in *B.C.A.*, 1926, B, 291); see also McBain and Lee, *B.C.A.*, 1928, B, 695); "Studies in Adhesion," by W. Hardy and M. Nottage (*Proc. Roy. Soc.*, 1926, A, **112,** 62); "Formation of Starch Paste," by S. V. Gorbatschev (*B.C.A.*, 1930, A, 1248); "Second Report of the Adhesives Research Committee" (H.M. Stationery Office); W. B. Lee (*Ind. Eng. Chem.*, 1930, **22,** 778); "Rubber Cements and Adhesives," by S. D. Sutton (*Ind. Chem.*, 1932, viii., 65); Agar-Agar, Algin, Bones, Briquetting, Gelatine, Glue, Gums, Isinglass, Mucilage and Size.

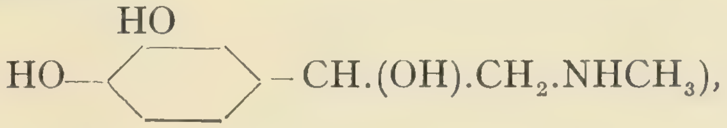
ADIPIC ACID ($C_6H_{10}O_4$ or $C_4H_8(COOH)_2$)—A member of the oxalic series of acids, a constituent of beet juice, and produced by the action of nitric acid upon oleic acid and other fatty acids. It is a solid crystalline body soluble in alcohol, ether, and hot water, of m.p. 153° C. A German process of manufacture, by the regulated oxidation of hydro-aromatic alcohols and certain ketones by potas-

ADIPIC ACID (*Continued*)—
sium permanganate, has recently been described, and the product adipic acid, with an acid number of 767, is stated to be superior to tartaric acid for use in making baking powder, salines, fruit essences, etc. (See W. Schrauth, *B.C.A.*, 1929, B, 163.)

ADIPOCERE—Fatty matter which is found in dead bodies buried under peculiar circumstances. According to one account it has an iodine value of 7·7 to 10·8, acid value 188 to 197, and m.p. 62° C. (See S. Joy, *B.C.A.*, 1922, A, 969, and 1927, A, 987.)

ADIPOSE (Substance)—Animal oil or fat.

ADRENALIN ($C_9H_{13}NO_3$)—A hormone (methyl-amino-ethanol-catechol, represented as—



being a nearly white crystalline substance constituting the active principle of the suprarenal glands, and prepared from those of sheep and cattle. It melts at from 205° to 212° C., and is slightly soluble in water, but insoluble in alcohol, ether, and chloroform, and is used in medicine. It affects the blood pressure and minute amounts are said to produce "all the vascular and visceral reactions which accompany the emotions of anger, excitement, and fright." The *l*-isomer is much more physiologically active than the *d*-isomer.

An artificial synthetic product less powerful in physiological action is known as suprarenin, and is a racemic modification of the natural lævorotatory compound prepared from pyrocatechol.

"ADSOL"—A form of fuller's earth.

ADSORPTION—See Colloid Chemistry, p. 227, and *Ind. Chem.*, 1929, v., 524.

AERATION—Charging of liquids with gases. So-called soda-water is water (with or without addition of a little alkali) charged with carbon dioxide gas under pressure. Water can also be charged with air or oxygen gas. Many natural sparkling waters are more or less charged with gases. (See *Ind. Chem.*, 1928, iv., 279.)

AERIAL—Character of air.

AEROLITES—See Meteorites.

AEROSOLS—See Colloid Chemistry, and Dusts.

ÆSCULIN—See Glucosides.

ÆTHER.—See Ether.

AFFINITY—See Chemical Attraction.

AGAR-AGAR (Galactan, Gelose)—A jelly-like preparation, soluble in water, made from certain seaweeds found in Japan and elsewhere in the East—chiefly of the genus Gelidium (class *Rhodophyceæ*)—and used as a nutrient material for bacterial growths, also as an adhesive,

AGAR-AGAR (Galactan, Gelose) (*Continued*)—emulsifier, sizing for silk, in medicine, and for veneering wood. It is chemically regarded as a sulphuric ester of gelose. Its manufacture in Japan and California is described in the *C.T.J.*, 1926, **79**, 366 and 1927, **81**, 54. For methods of testing agar and gelatin jellies, see Gelatin, p. 397. The identification of agar-agar by the presence of the diatoms associated with it as normally prepared is dealt with by J. King (see *Analyst*, 1925, **50**, 371); M. Lüdtke (*B.C.A.*, 1929, A, 1347); Algin and Seaweeds.

AGATE—An anhydrous form of natural silica (SiO_2) of crystal system, No. 3, being a variegated *chalcedony* found in many parts of the U.S.A. and elsewhere. Some analyses of agate are given by H. Heinz (*B.C.A.*, 1930, A, 1016). (See Silicon.)

AGAVE—See Alcohol (Ethyl).

AGITATION—See Grinding and Mixers.

" AGRAL "—A tar oil emulsifying agent.

AGRICULTURAL CHEMISTRY—See Vegetation.

AIR (Atmosphere)—To the height of about 10 kilometres the air, owing to the laws of diffusion and the action of winds, is practically of almost uniform composition, the temperature falling steadily with height and then remaining fairly constant until about 60 kilometres, when it begins to fall again. In the higher regions above some 8 miles the temperature is stated to become tropical in character.

Air is substantially a mixture of oxygen gas (about 21 parts) and nitrogen gas (about 79 parts), containing small quantities of other gases, also varying proportions of moisture (water) in consequence of the continuous evaporation of water from the land and water surfaces of the earth. For any given temperature, there is a maximum amount of water vapour which a given volume of air is capable of taking up or dissolving, and under these conditions it is saturated with moisture at that particular temperature. (See Hygrometers.)

A cubic metre of air at 20° C. can take up 17·157 grms. of water, but at 0° C. it can only hold 4·87 grms., so that, when cooled, the excess of water held in gaseous solution is deposited as mist, dew, rain, hail, or snow.

Animal life could not exist without the oxygen content of the air. In breathing, the oxygen of the air is sucked up or absorbed in the lungs, and reacting upon the blood forms carbon dioxide, which gas is given out in the breath—the act of respiration. The inert nitrogen which is present in the air is of no direct use of sustaining life, but makes the oxygen dilute enough to enable this to be done, as pure oxygen is fatal to human life when continuously breathed.

It has been estimated that the amount of carbon dioxide given off in each twenty-four hours through the lungs of an adult human being is that which results from the oxidation of between 7 and 11 ounces of carbon, and this necessitates the consumption of about 1½ pounds of oxygen gas inhaled; and if we multiply this quantity by the number

AIR (Atmosphere) (*Continued*)—

of the world's inhabitants (human beings and animals) the amount of oxygen gas thus removed from the air is represented by an astounding figure. The quantity, indeed, is so large that, unless there existed some compensating process, life would in course of time become impossible on the earth. It is now known that plant life gives back to the atmosphere the oxygen which animal life removes from it. This is the more important because, whereas 100,000 parts of air ordinarily contain only up to 33 parts by volume of carbon dioxide, larger proportions would foul it to such an extent as to produce headache and other sickness, while the presence of from 200 to 300 parts is seriously prejudicial to health. Vegetable life absorbs carbon dioxide from the air, as also from decomposing organic matter in the soil, and, assimilating the carbon in its tissues by a variety of chemical processes, gives out again its oxygen content, and thus maintains the composition of the air practically constant and universal. (See Hæmatine, Photocatalysis, Respiration, and Vegetation.)

It is the oxygen of the air that sustains the combustion of fuel in fire-grates, the carbon (of which fuels are largely composed) entering into chemical combination therewith, forming carbon dioxide, and giving out heat at the same time.

Combustion is essentially dependent upon the presence of oxygen. If an ordinary night-light be lighted and placed in a wide-mouthed stoppered bottle, and the bottle closed, the night-light will go on burning until the oxygen contained in the air present in the bottle has been used up: on the other hand, as is well known, it will go on burning in the open air until it is all consumed.

The air always contains a certain quantity of carbon dioxide—averaging 0·03 per cent. in fresh air—and this constituent is of more importance than might appear without careful consideration, bearing in mind how essential it is to the growth and development of vegetable life, and how the quantity of oxygen contained in the air is maintained by way of compensation.

In addition to moisture and dust, the air of towns generally contains small proportions of ammonia, sulphur dioxide, hydrogen sulphide, and organic matters, whilst nitric acid is produced by lightning flashes. Appliances known as "Dust Counters" can be employed for measuring atmospheric pollution by dust. At times, ozone in small proportion also forms an aerial constituent, particularly in the upper layers, whilst recent investigations have revealed the presence, as normal constituents, of a number of rare gases in minute quantities, including argon, helium, neon, krypton, and xenon. The relative proportions in which these are present are shown below:

Argon	0·937	part	in	100 air.
Helium	1	part	in	250,000 air.
Neon	1 to 2	parts	in	100,000 air.
Kryton	1	part	in	1,000,000 air.
Xenon	1	part	in	20,000,000 air.

AIR (Atmosphere) (*Continued*)—

According to J. W. Hershey (*Science*, 1930, **74**, 394), the rare gases appear to be essential to the normal life of mice in an atmosphere of 21 per cent. oxygen and 70 per cent. nitrogen. (See *B.C.A.*, 1930, A, 941.)

The weight of a litre (1,000 c.c.) of air at 0° C. and 760 mm. of pressure is 1·2932 grms. Its density diminishes as the altitude increases and its constantly varying pressure can be registered at the earth's surface by means of the barometer.

Air is commercially liquefied by self-intensive processes depending upon the performance of internal, or both internal and external work, as in the "Linde" and "Claude" processes respectively. In the Linde process air purified from carbon dioxide and water is allowed to expand from a pressure of from 150 to 200 atm. within the coil of the atmosphere to slightly above that of the atmospheric pressure outside the nozzle, thus realizing a liquefaction of about 5 per cent.; whereas, in the Claude process, the air is compressed to from 40 to 50 atm. and then divided into two parts, one of which is allowed to expand in a vessel to perform external work and become cool and then made to surround the other part which is sufficiently cooled to liquefy by free expansion. As oxygen is more condensable than nitrogen, the liquefied product contains a larger proportion of oxygen than ordinary air. It is a mobile liquid of slightly bluish tint, and density near that of water, of b.p. $-191°$ C., but it cannot be preserved and transported in steel cylinders, as its critical temperature is $-140°$ C.—that being the maximum temperature at which it can exist irrespective of pressure.

Liquid air is so cold that when such materials as flesh or india-rubber are cooled in it they become brittle, and when struck with a hammer fly into pieces as glass does. (See *Ind. Chem.*, 1927, iii., 488; other references—H. Osborne on "Atmospheric Pollution" (*Analyst*, 1925, **50**, 23); J. B. C. Kershaw (*Ind. Chem.*, 1926, ii., 153); S. Lancefield on "Air Filtration in a Food Factory" (*Ind. Chem.*, 1930, vi., 452); W. C. Reynolds on "London and Suburban Air" (*J.S.C.I.*, 1930, **49**, 169 T); Tankard and Bagnall on "Fatalities due to Vitiated Air produced by Oxidation of Vegetable Refuse" (*Analyst*, 1930, **55**, 673); R. C. Parmelee on "Industrial Air Conditioning" (*C.T.J.*, 1931, **89**, 387); Reports of the Advisory Committee of the Meteorological Office on Air Pollution (H.M. Stationery Office), (*Analyst*, 1930, **55**, 755); also Air Tester, Barometer, Explosives, Oxygen, Smoke, and Ventilation.)

AIR LIFTS—Pumping and agitating devices which work in two ways—viz., continuously, as in the Frizell system, and intermittently, as in the Pohlé type—used, for example, for circulating nitric acid in absorbing towers, lime mixing, conveying hot brine, mixing dyestuffs without mechanical agitator, etc., and forming an integral part of plant in cases where liquids are heated by the submerged flame burner. (See N. Swinding, *Chem. and Ind.*, 1928, **47**, 1345.)

AIR-PUMPS—Mechanical appliances provided with valves, used for pumping air into or withdrawing (exhausting) it from vessels. Amongst other applications, air-pumps are used in laboratories in association with desiccators for evaporating operations conducted at the ordinary temperature of the atmosphere in order to reduce the atmospheric pressure and thus promote the evaporation from the containing vessel, and at the same time to remove the aqueous vapour (coming from the substance being desiccated) contained in the attenuated space, which may not already have been absorbed by any appliance placed therein for that purpose. An air-compressor for small laboratories is described in the *Ind. Chem.*, 1930, vi., 41. (See Desiccator, Evaporation, and Pumps.)

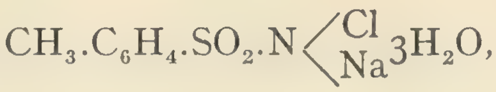
AIR TESTER—An appliance useful in investigations of ventilation conditions. (See R. Frederick, *Analyst*, 1926, **51**, 397, and Ventilation.)

AJOWAN OIL—Expressed from the seeds of *Carum ajowan*, supplies coming from Egypt, Persia, and India. The yield is about 3 to 4 per cent. of oil having a sp. gr. of from 0·900 to 0·930, and refractive index 1·471 at 35° C., containing from 40 to 55 per cent. thymol associated with cymene and terpenes. The cake is stated to contain about 0·9 per cent. nitrogen in a readily suitable condition for use as a fertilizer. (See Thymol.)

"AKRITE"—See "Stellite."

"AKTIVIN" (Sodium *p*-toluene sulphochloramide)—A German product said to contain a quantity of readily available chlorine, being a refined kind of "Zauberin"; described as a hydrolysing agent useful for converting starch into a soluble form yielding a clear solution which gives no reaction with the iodine test and yet free from dextrine. This solubility makes it possible to clear out all size when undressing textile fabrics.

It is described as having the formula



$\mathrm{CH_3.C_6H_4.SO_2.N}\langle^{\mathrm{Cl}}_{\mathrm{Na}}\,\mathrm{3H_2O}$,

and stated to be more suitable than other agents for the treatment of fabrics before or after printing than oxidizing or bleaching agents. (See Chloramine T, Peractivin, and "Zauberin.")

ALABASTER—A native form of fine-grained gypsum ($CaSO_4$), used in sculpture and for ornamental applications. (See Calcium.)

"ALACET"—Trade name for formic acid.

ALBERTA SANDS—See Asphalt.

"ALBERTOL"—Synthetic resins, described in the U.S.A. as "Amberol" resins, one such article being made by heating a mixture of 160 parts phenol with 40 of rosin and 40 of para-formaldehyde for 6 hours at 120° to 130° C. (See T. H. Barry, *Ind. Chem.*, 1928, iv., 501, and 1930, vi., 69; also Anon. and E. Fonrobert, *B.C.A.*, 1930, B, 676.)

"ALBILITH"—An American type of lithopone paint, being a composition of "XX" zinc oxide (lead free) 40 parts, lithopone 40 parts, silica 10 parts, and asbestine 10 parts. (See *C.T.J.*, 1920, **66,** 486.)

ALBUMINATES—Loose combinations of albumin with metals, such as the copper compound resulting from the addition of copper sulphate to a solution of albumin.

ALBUMINOID AMMONIA—That resulting from the decomposition of albuminous matter, serving, when determined, as indicative of the organic nitrogen content of water supplies.

ALBUMINOIDS—See Albumins and Proteins.

ALBUMINOMETER (Esbach's)—A graduated tube about 6 inches long and ½ inch diameter, graduated so that each degree indicates 0·1 per cent. of albumin. The tube is filled to a given mark with urine, and a reagent of 1 per cent. picric acid and a 2 per cent. solution of citric acid in distilled water is then added up to another mark. This causes the precipitation of any albumin contained in the urine, and after settlement the volume is read off by the graduations on the tube.

ALBUMINS—Substances constituting one of the principal divisions of the larger group of so-called albuminoids or "proteins" which make up the chief part of the flesh of animal organisms and are contained in protoplasm and plants (especially in the seeds). They are largely built up of aliphatic groups, and some of them, such as chitin, yield carbohydrates upon hydrolysis. There are many distinct individuals, including egg-albumin, serum-albumin, and lact-albumin (from milk), being generally uncrystallizable nitrogenous bodies of complicated composition containing:

Carbon from 52·7 to 54·5 per cent.,
Hydrogen from 6·9 to 7·3 per cent.,
Nitrogen from 15·4 to 17·6 per cent.,
Oxygen from 20·9 to 23·5 per cent., and (some of them)
Sulphur from 0·8 to 5·0 per cent.,

approximately represented by the formula $C_{72}H_{112}N_{18}SO_{22}$.

As exceptions to the general rule, the albumins found in hemp, castor oil, and pumpkin seed have been described as crystalline.

Some nearly allied bodies do not contain sulphur, although there is in all probability a family resemblance and more or less common structure.

Some are more or less soluble in water, and most of them are soluble in dilute alkaline and saline solutions, and are precipitated therefrom by alcohol. When their solutions are heated they become coagulated at from 70° to 75° C., particularly in the presence of acetic acid.

They are changed by mild processes of hydrolysis (as induced by the action of dilute acids or alkalies, as also by the enzymes which take part in the processes of digestion) into so-called albumoses (proteoses) or peptones, which are soluble in water, and thus become available for assimilation. When the hydrolysis is carried still further, a variety

ALBUMINS (*Continued*)—
of other products result, ultimately terminating with a number of substances termed amino-acids, one of the best known of which is tyrosine. (See Polypeptides.)

The putrefaction of albumins, caused by the action of microbes, results in the production of many derivatives, including some alkaloidal substances called *ptomaines* or toxins, which are highly poisonous, and two of which have been isolated—viz., " putrescine " (tetramethylene diamine), which has been synthesized, and " cadaverine " (pentamethylene diamine, $NH_2.(CH_2)_5.NH_2$).

The white of egg is a typical albumin, of which large quantities are used in France for the clarification of wines, also in the leather industry and photography. The albumins form loose indefinite combinations with metals known as Albuminates. (See H. H. Dale on "Viruses" (*Chem. and Ind.*, 1931, **50,** 827); also Blood Albumin, Casein, Nucleins, Peptones, Proteins, Ptomaines, and Pus.

ALBUMOSES—See Albumins and Proteins.

"ALCOBRONZE"—See Copper, p. 238.

ALCOHOL—Spirits of wine, of indefinite alcoholic strength.

Alcohol Table, showing the Specific Gravities of Various Strengths.

Absolute Alcohol per Cent. by Volume.	Absolute Alcohol per Cent. by Weight.	Sp. Gr. at 15·5° C.	Absolute Alcohol per Cent. by Volume.	Absolute Alcohol per Cent. by Weight.	Sp. Gr. at 15·5° C.
1	0·80	·9985	55	47·29	·9242
5	4·00	·9928	60	52·60	·9134
10	8·05	·9866	65	57·24	·9020
15	12·05	·9810	70	62·50	·8899
20	16·28	·9760	75	67·93	·8772
25	20·46	·9709	80	73·59	·8637
30	24·69	·9654	85	79·80	·8494
35	28·99	·9591	90	85·75	·8337
40	33·39	·9518	95	92·40	·8159
45	39·90	·9435	100	100·00	·7939
50	42·52	·9343			

(See Alcohols (Ethyl), Fermentation, Methylated Spirit and Proof Spirit.)

ALCOHOL (SOLIDIFIED)—A commercial article of this name is composed of alcohol, or alcohol and methylated spirit, with soap. One formula is—alcohol, 60 parts; methylated spirit, 40 parts; and sodium stearate, about 3 parts. Other jellifications are known; among them,

ALCOHOL (SOLIDIFIED) (*Continued*)—

German productions of the nature of ethyl alcohol gels. (See *C.T.J.*, 1928, **83**, 420.)

ALCOHOLATES—Analogous compounds to hydroxides; the groups O,CH_3 and O,C_2H_5, etc., take the place of OH—*e.g.*, sodium alcoholate (NaO,C_2H_5).

ALCOHOLOMETRY—An alcoholometer is an apparatus (resembling an ordinary graduated hydrometer) used to determine alcoholic strength of liquids. An account of the British method of strength determination, by F. G. H. Tate, is published by H.M. Stationery Office (1930).

ALCOHOLS—There are several classes of alcohols, all of which are characterized by their content of one or more hydroxyl groups, and described as monohydric (monatomic), dihydric, and trihydric, according to the number of these. The normal monohydric alcohols constitute a series of homologous (aliphatic) bodies of ascending specific gravities and boiling-points, the lower members being colourless mobile liquids, the middle ones of more oil-like character, and the higher ones solid, like paraffin in appearance and without taste or colour. A large series are found in nature in combination with organic acids in essential oils and waxes.

Methyl Alcohol (**Methanol, Carbinol, Wood Naphtha, Wood Spirit**), CH_3OH (or CH_4O), is contained in combination with salicylic acid in oil of winter-green, and is found among the products of the distillation of wood, the yield therefrom being increased by as much as 50 per cent. without lessening the production of acetic acid by adding a small amount of sodium carbonate before distillation.

A catalytic process has been devised for producing methyl alcohol from water-gas, the involved equations being represented as follows:

$$\begin{array}{c} CO_2 + 2H_2 = CH_3OH \\ \hline CO + H_2 = HCHO \end{array}$$

and

$$HCHO + H_2 = CH_3OH.$$

That is to say, formaldehyde is probably formed as an intermediary product and then at once hydrogenated to methyl alcohol.

Newitt and Haffner have quite recently succeeded in making it by the direct interaction of oxygen and methane under certain conditions. (See letter of W. A. Bone (*Nature*, March 28, 1931).)

Methyl alcohol is made on a large scale by heating water-gas, or hydrogen-gas in admixture with carbon monoxide, under high pressure in presence of a suitable catalyst. "Methanol Condensation as modified by Alkalized Catalysts," by G. T. Morgan (with others) (*Chem. and Ind.*, 1932, **51**, 1 T); its synthetic production by an American plant (*C.T.J.*, 1930, **87**, 326). A study of its synthesis by this process, using various catalysts, has been made by E. Audibert (*B.C.A.*, 1929, B, 162, and by V. A. Plotnikov (with others) (*B.C.A.*, 1931, B, 530); see also Brown and Galloway (*B.C.A.*, 1929, B, 426), Smith and Hirst

ALCOHOLS (*Continued*)—

(*Ind. Eng. Chem.*, 1930, **22,** 1037), Frolich and Cryder (*Ibid.*, 1051), and H. S. Taylor (*Chem. and Ind.*, 1931, **50,** 317). On the one hand, it has been stated that it can be used satisfactorily alone or in admixture as a fuel, provided it can be produced cheap enough, but according to W. R. Ormandy it is ruled out as a motor fuel because it will not stand a high compression and as its heat value is less than one-half that of petrol. (See *C.T.J.*, 1928, **83,** 570; and Brown and Galloway, *B.C.A.*, 1930, B, 359.) (See "Synthol.")

It is a limpid, colourless, volatile liquid of b.p. 67° C., sp. gr. 0·7851; burns with a non-luminous flame, and is a solvent of fats, oils, aniline dyes, formaldehyde, perfumes, etc. It is soluble in water, and is used commercially in the synthesis of dyestuffs, in making formaldehyde, spirit varnishes, polishes, and for "methylating" spirits of wine. Upon oxidation it yields formaldehyde (CH_2O), and finally formic acid (CH_2O_2). (See Methylated Spirit.)

Ethyl Alcohol (Absolute Alcohol, Ethanol, Ordinary Alcohol, Spirits of Wine, or **Grain Spirit**) (C_2H_5OH or C_2H_6O)—Pure alcohol is a limpid, colourless, volatile, inflammable liquid of sp. gr. 0·8063 at 0/4° C., and b.p. of 78·4° C. at 760 mm. pressure. By oxidation, it is converted into acetaldehyde (C_2H_4O), and finally acetic acid ($C_2H_4O_2$). It is the product of the fermentation of sugar (glucose), and the intoxicating principle of wines, beers, and spirits (gin, whisky, brandy, and rum). The physical properties of absolute alcohol have been examined by Barbaudy and Lalande (*B.C.A.*, 1930, A, 1356).

Alcohol is prepared commercially from the starches of cereals or potatoes and from sugar and molasses by processes of fermentation. Ten tons of potatoes with a starch content of 37 cwts. will yield on average 255 gallons alcohol, while a corresponding weight of grain yields 670 gallons.

Indian ghur molasses yields from 78·5 to 85 per cent. alcohol, while the real sugar in the molasses should give from 95·5 to 99·2 per cent., the low yield being due, according to Gupta and Watson, to the presence of a gum resistant to acid hydrolysis which yields mucic acid. The production of industrial alcohol from molasses, as carried out by the Solvent Products, Ltd., using pure yeast cultures, is described in the *Ind. Chem.*, iv., 141. (See Eyre's lecture referred to under Fermentations and Molasses.)

It can also be produced from the waste sulphite liquors of paper-pulp mills containing carbohydrates. The starches are first converted into maltose by the action of malt, or otherwise, the extract or "wort" being then subjected to fermentation as in brewing, and subsequently distilled in order to obtain the alcohol thus produced. (See Paper.)

In the Philippine Islands and North Borneo, alcohol is made on a commercial scale from the sap of the Nipa palm, although the production of sugar from that source was, until recently, only in the experimental stage, and the "alcohol equivalent" of the juice is said to be 10·09 per cent.

ALCOHOLS (*Continued*)—

Agave pulp prepared from the so-called American aloe (*Agave americana*), many species of which grow in Mexico and Central America, is used as the source of native alcoholic drinks, containing, as it does, a considerable percentage of sugar, and has been suggested as a good possible source of alcohol. The dry pulp is stated to contain up to 15 per cent. fermentable sugars.

Alcohol is also made to some extent from wood-waste and sawdust by hydrolytic conversion of their cellulose contents into saccharoids and subsequent fermentation. Dangeville's process for the hydrolysis of cellulose consists in treating the material with concentrated hydrochloric acid in two steps, the first part being accomplished by the action of gaseous acid on the moistened material, and the acid, after absorption and dilution with water, being utilized to carry out the secondary hydrolysis at the boil. Operating in this way, a yield of 67·6 per cent. of glucose has been obtained from pine wood, 62·59 per cent. from wood pulp, 59·54 per cent. from rye straw, and 70·43 per cent. from bleached sulphite cellulose. Larch wood has proved to be one of the most promising sources of ethyl alcohol as tested by the United States Forest Products Laboratory. (See Glucose and Wood.)

A method for production of a motor fuel consisting of ethyl alcohol and acetone from maize cobs, etc., by hydrolysis with dilute acids and subsequent fermentation by the use of the pentose fermenting *Bacillus acetoethylicus* (Northrop), is described by Thayser and Galloway in the August, 1928, issue of the *Annals of Applied Biology,* **15,** no. 3.

It is reported that a new bacillus has been found which is capable of directly fermenting cellulose materials into a variety of products, including alcohol, under either anaerobic or aerobic conditions.

The " Amylo " process carried on near Lille depends upon the use of certain moulds, such as the *Aspergillaceæ,* for saccharifying starch (such as that of maize, rice, potatoes, etc.) instead of malt—the *Rhizopus delemar* or *Mucor boulard* being now almost exclusively employed—thus avoiding the formation of the unfermentable dextrins which result to some extent when malt is used. A mash of sp. gr. 1·060 is made by steaming the starch material under pressure in a cooker, and after injection into the fermenting vessel, is cooled to 40° C., when the active culture of the mould is introduced. The yeast (*Amylomyces*) used for fermenting the material thus prepared exercises its optimum effect in a slightly acid admixture at 38° C., and the process, which takes in all four days to complete, yields up to 97·5 per cent. of the alcohol theoretically obtainable. This process cannot be used in this country for statutory reasons, inasmuch as at no stage of the procedure can the specific gravity of the wort be taken before fermentation.

An improved method of obtaining absolute alcohol from fermented liquids by the azeotropic method of distillation is described by H. Guinot (*B.C.A.,* 1930, B, 527).

Attempts have also been made to produce ethylic alcohol from the ethylene contained in coke-oven gases by absorbing it in 95 per cent. sulphuric acid, and hydrolysing the ethyl sulphate thus produced, by

ALCOHOLS (*Continued*)—

dilution of the acid mixture with water or steaming, thus producing alcohol which is recovered by distillation and regenerating the sulphuric acid. In a modification of this process a minimum of acid is employed and the product is decomposed by rapid hydrolysis with ammonia. Of course the gas, prior to this procedure, is freed from tar, ammonia, naphthalene, benzol, sulphuretted hydrogen, the higher olefines, and water vapour in the order as here given. It is on record that 1·6 gallons of alcohol can be thus obtained from each ton of the particular Durham coal employed. A description of this process and plant established at Bethune will be found in the *C.T.J.*, 1925, **76**, 753.

The Jerusalem artichoke has long been recognized as a possible raw material for production of power alcohol, and Government experiments have shown a yield of about 18·7 gallons per ton of tubers.

Some interesting particulars concerning the vegetable sources of industrial alcohol are summarized from the Kew Bulletin of Miscellaneous Information, 1925, in the *Analyst,* l., 404.

Alcohol can be synthetized from acetylene as produced from calcium carbide by the chemical change represented as follows:

$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2,$$

the acetylene thus produced being next transformed into acetaldehyde by hydration in presence of a suitable catalyst such as mercuric oxide in sulphuric acid solution—

$$C_2H_2 + H_2O = CH_3.CHO,$$

and by catalytic hydrogenation over reduced copper or nickel or electrolytic hydrogenation the acetaldehyde is finally converted into alcohol—

$$CH_3.CHO + H_2 = CH_3.CH_2.OH.$$

These changes are all realizable on a large scale, but, according to one account, while 110 gallons of alcohol can be obtained from 1 ton of carbide, the same quantity of carbide, if used for making calcium cyanamide, and that product be then used as fertilizer, the nitrogen thereby rendered available—viz., 550 to 600 pounds—should result in an increase of more than 20 tons crop yield, and 20 tons of potatoes yield 400 gallons alcohol—that is, practically four times the quantity obtainable direct from the carbide. At the same time it has been argued that, given sufficiently cheap electrical power, alcohol can be manufactured in this way at a price low enough to compete with petrol and benzol as a power unit. (See *C.T.J.*, 1927, **81,** 583.)

In the high-pressure catalytic production of methyl alcohol from hydrogen and carbon monoxide gases some proportion of ethyl alcohol is also formed, and under certain conditions this proportion can be considerably increased. The synthetic production of ethyl alcohol by a modified process of this character is receiving the attention of research workers. (See *C.T.J.*, 1930, **86,** 592, and 1930, **87,** 262; also Morgan and Taylor (*Proc. Roy. Soc.*, 1931, **A, 131,** 533).)

Several scale model plans are now at work making ethyl alcohol

ALCOHOLS (*Continued*)—

from water-gas mixtures at the rate of 1 gallon alcohol per 1,000 feet of gas.

Although its calorific value is not much more than one-half that of petrol, its efficiency is much greater owing to its relatively greater combustion. It can be compressed to a greater extent, and this property of high-ignition temperature under compression is not materially altered by admixture with 20 per cent. benzene or petrol. Such a mixture readily starts in the cold and runs smoothly; so that if alcohol could be manufactured sufficiently cheap it would become a serious competitor with petrol as a fuel for internal combustion engines. (See King and Manning on "Alcohol Fuels" (*B.C.A.*, 1929, B, 1040.)

"Alcohol as a Motor Fuel," alone or in admixture, is the subject of a paper by Ross and Ormandy (*J.S.C.I.*, 1926, **45,** 273) and the abstract of a paper by Colonel Sir F. Nathan on "Alcohol for Power Purposes" is given in the *Ind. Chem.*, 1928, iv., 421.

The importance of obtaining power alcohol in the anhydrous state, and methods of doing this, are dealt with in a paper by H. Guinot, reproduced from *The International Sugar Journal* for February, 1930, in the *C.T.J.*, 1930, **86,** 201.

Alcohol is soluble in water, and is largely used as a solvent, in the manufacture of explosives, chemicals, perfumes, lacquers, pharmaceutical extracts and tinctures, also as a fuel, in the compounding of drinks, and for preserving anatomical specimens. It would be much more extensively used, but for the legal restrictions on its use which have largely led to the employment of other organic solvents. When alcohol is diluted with water there is a contraction in volume. (See H. P. Foran, *J.S.C.I.*, 1924, **43,** 338 T; Fermentations and Wine.)

Propyl Alcohol (normal) (C_3H_7OH or $CH_3.CH_2.CH_2.OH$ or C_3H_8O) is a spirituous colourless liquid which can be obtained from fusel oil. It boils at 97·4° C., and has a sp. gr. of 0·817. By oxidation it yields propylaldehyde (C_3H_6O), and finally propionic acid ($C_3H_6O_2$). (See Isopropyl Alcohol.)

Butyl Alcohol (normal) (C_4H_9OH or $CH_3.(CH_2)_3.OH$ or $C_4H_{10}O$) is a limpid, colourless liquid of b.p. 118° C., sp. gr. 0·823, flash-point about 85° F.; soluble in water and alcohol, and by oxidation yields butyric acid ($C_4H_8O_2$). It is used as a solvent in the saponification of fats resistant to ordinary alcoholic soda, also to some extent in making fruit essences, and as a source of butadiene for the manufacture of synthetic rubber. Its production from maize is referred to under the heading of Acetone.

The normal secondary butyl alcohol ($CH_3.CH_2.CH(OH).CH_3$) is a thin colourless liquid of pleasant odour, sp. gr. 0·803 and b.p. 77·8° C., soluble in water and alcohol, used in perfumery and making fruit essences. The normal iso-butyl alcohol ($(CH_3)_2.CH.CH_2.OH$) is a colourless mobile liquid of sp. gr. 0·806 and b.p. 107° C., soluble in water and alcohol, used for the same purposes as the normal secondary alcohol. The tertiary butyl alcohol ($(CH_3)_3C.OH$) is a white crystalline substance of camphor-like odour of sp. gr. 0·786, m.p. 25·5° C., and

ALCOHOLS (*Continued*)—

b.p. 83° C., soluble in water and alcohol, used in making fruit essences, etc.

There are further members of this series of so-called monohydric or aliphatic alcohols, including—

Amyl Alcohol (Normal) ($C_5H_{11}OH$ or $CH_3(CH_2)_4OH$)—The normal amyl alcohol is colourless, of disagreeable odour, b.p. 138° C., sp. gr. of 0·817, and flash-point about 105° F. The ordinary amyl alcohol of commerce is the iso-amyl alcohol ($(CH_3)_2.CH.CH_2.CH_2.OH$) as produced in processes of fermentation and contained in fusel oil, particularly that found in the last runnings of fermentation alcohol from potatoes and molasses. It is generally lævorotatory in character; is soluble in water, alcohol, and ether, and of b.p. 131° C., and sp. gr. 0·810.

It is made in large quantities as a solvent of cellulose in making so-called "dope" for use in connection with the manufacture of aeroplanes.

There are no less than eight isomeric forms of amylic alcohol of boiling-point varying from 102° to 138° C., and several of these are contained in fusel oil, of which, however, the chief constituent is the iso-amyl alcohol. The manufacture of amyl alcohol by the action of chlorine on pentane is described by E. E. Ayres (*Ind. Eng. Chem.*, October, 1929), and notes on this process are given in the *C.T.J.*, 1929, **85,** 392, and 1931, **88,** 485. (See Dope, Fusel Oil, and "Pentasol.")

n-**Hexyl Alcohol** ($C_6H_{13}OH$ or $CH_3(CH_2)_5OH$) boils at 157° C., and has a sp. gr. of 0·833.

n-**Heptyl Alcohol** ($C_7H_{15}OH$ or $CH_3(CH_2)_6OH$) boils at 176° C., and has a sp. gr. of 0·836.

n-**Octyl Alcohol** [$C_8H_{17}(OH)$ or $CH_3(CH_2)_7OH)$] boils at 195° C., and has a sp. gr. of 0·839.

In **Benzyl Alcohol** ($C_6H_5.CH_2.OH$) the alkyl residue is replaced by an aromatic nucleus, and this is true of all the alcoholic derivatives of the carbo-cyclic series, but the alcoholic hydroxyl group is never united directly to a carbon atom of the aromatic ring. In so-called secondary alcohols like menthol the secondary group OH may be attached to a cyclic carbon; they are not oxidizable to acids but to ketones (see Isopropyl Alcohol), while the tertiary alcohols yield upon oxidation ketones or acids containing fewer atoms of carbon.

The glycols or dihydric alcohols can be regarded as derived from paraffins, in which two hydrogen atoms are replaced by two hydroxyl groups, and include ethylene glycol ($C_2H_6O_2$ or $C_2H_4,2HO$), propyl glycol ($C_3H_8O_2$ or $C_3H_6,2HO$), and butylene glycol ($C_4H_{10}O_2$ or $C_4H_8,2HO$), and so forth. They are mostly thickish liquids of somewhat sweet taste, readily soluble in water and alcohol. (See Ethylene Glycol.)

Of the trihydric alcohols, glycerol (glycerine) is a member and illustrative, its formula being $C_3H_8O_3$ or $C_3H_5,3HO$. (See Aromatic Alcohols and Glycerol.)

ALDEHYDES—A series of organic bodies (mostly liquids) related to the alcohols and the ethers, formed by the elimination of two atoms of hydrogen, by oxidation of the alcohols, or dehydrogenation therefrom (C_2H_5HO less $H_2 = C_2H_4O$). The dehydrogenation method, which is carried out by the passage of the alcohol vapour through a heated copper spiral at 300° C., gives a better yield than the oxidation method. (See S. S. Willimott, *Analyst*, l., 13.) This relationship is illustrated by the following equation in the case of oxidation of ethyl alcohol: $C_2H_5HO + O = C_2H_4O + H_2O$. By further oxidation, the aldehydes so produced are converted into a corresponding series of acids; thus ethyl aldehyde becomes oxidized to acetic acid—

$$C_2H_4O + O = C_2H_4O_2.$$

The lower members of the aldehydes are neutral volatile liquids of characteristic odour, soluble in water, with lower boiling-points than those of the corresponding alcohols.

These aldehydes are easily reconverted into their corresponding alcohols by the action of nascent hydrogen; thus the ethyl or acetic aldehyde is changed back to ethyl alcohol, as shown in the equation—

$$C_2H_4O + H_2 = C_2H_5HO.$$

This can be realized, for example, by passing its vapour with hydrogen gas over finely divided copper or nickel at 120° to 300° C. With copper the yield is 87·6 per cent. at 200° C.

It is the **Ethyl Aldehyde** (CH_3CHO) that is commonly known as acetaldehyde or "aldehyde" and otherwise as "ethanal," and is ordinarily prepared by the oxidation of ethyl alcohol by means of potassium dichromate or manganese dioxide and sulphuric acid. By another process used in France it is made by passing acetylene into dilute sulphuric acid containing a small proportion of mercury sulphate. It is a colourless, mobile, inflammable, volatile fluid of a peculiar pungent odour, of b.p. 22° C. and sp. gr. 0·801; miscible with water, alcohol, and ether, and possesses strong reducing properties. (See Reducing Agents.) Apart from its chemical applications, it finds use as a solvent; as an antiseptic inhalant in cases of nasal catarrh and ozæna, while recently it has been shown by the Food Investigation Board that healthy fruit can be treated with concentrations of it strong enough to destroy fungal spores and fungal mycelium, without ill-effects on the fruit. (See Report for 1929.)

Methyl Aldehyde (CH_2O), the next lower member of the series, is, in its normal state, an exception to the rule above stated, being a gas, and is produced as described under Formaldehyde, which is the common name for it:

$$CH_3HO \text{ (methyl alcohol)} + O = CH_2O + H_2O.$$

It is otherwise known as "methanal." (See Formaldehyde and Paraform.)

The aromatic aldehydes corresponding to the aromatic alcohols are largely used in perfumery. (See Perfumery.)

ALDHOSES—See Carbohydrates.

"**ALDUR**"—A window-glass substitute, being a formaldehyde-urea condensation product.

"**AL-DUR-BRA**"—An aluminium brass of corrosion-resisting property.

ALEMBROTH (SALT OF)—A crystalline compound of mercuric chloride and ammonium chloride ($2NH_4Cl,HgCl_2,H_2O$), prepared by mixing solutions of the two salts in suitable proportions.

ALFA (Alva)—See Esparto Grass.

ALFALFA (*Stipa tenacissima*)—Spanish name for lucerne, used for the same applications as esparto grass. (See Esparto Grass and Lucerne.)

ALGÆ—An order of flowerless plants, including the seaweeds (*fucus*) and the fresh-water confervæ. (See *Ind. Chem.*, 1932, viii., 35; Seaweeds and Vegetation.)

ALGIN (Norgin)—A gelatinous (albuminous) material, being a sodium salt of alginic acid (obtained from seaweeds), used as an adhesive and food. It is made by soaking the marine algæ for twenty-four hours in a 1 per cent. solution of sodium carbonate, filtering the viscous liquor through cloth, and precipitating it therefrom by dilute sulphuric acid, washing and drying. The compounds of algin give very viscous solutions, and are valuable as sizings for textiles and paper, as thickenings for printing colours, and as proofings for interior walls and ceilings.

The sodium compound is soluble in water, and a 5 per cent. solution is so viscous that it can hardly be poured out from its containing vessel.

The heavy metallic compounds are insoluble in water, but some are soluble in ammonia, and these solutions are used as waterproofing materials for textiles. (See *Bulletin Imperial Inst.*, vol. xxix., no. 2, 1931, or *C.T.J.*, 1931, **89**, 83.)

ALIGNMENT CHARTS—See Nomograms (respecting chemical plant).

ALIPHATIC—The distinctive term applied to acyclic hydrocarbons and all carbon compounds with open chains (as those derived from the acetylene, paraffin, and olefine hydrocarbons), and as distinct from those containing an aromatic nucleus. The fatty acids are, for example, members of the aliphatic series. (See Chains.)

ALIQUOT—A definite proportion of a given quantity.

ALIZARIN (Dihydroxy-Anthraquinone, 1 : 2) ($C_{14}H_8O_4$ or $C_6H_4(CO)_2C_6H_2(OH)_2$)—An important colouring matter, prepared from the roots of the madder plant (*Rubia tinctorum*), in which it is contained in the form of a glucoside, and now made on an extensive scale by a synthetic process from anthracene. Anthracene is oxidized into anthraquinone; the product is sulphonated and then fused with caustic soda and potassium chlorate, after which the fused mass is dissolved in hot water and the alizarin precipitated out of solution by addition of hydrocloric acid. Its preparation from phthalic anhydride and *o*-dichlorobenzene is described by M. Phillips (*B.C.A.*, 1927, A, 362), and its synthesis is the subject of a paper by A. Robertson (*J.C.S.*, 1930, p. 1136). It crystallizes in fine red prisms and needles, of m.p. 289° C.; is sublimable, and

ALIZARIN (**Dihydroxy-Anthraquinone**) (*Continued*)—
soluble in alcohol and ether, but only to a small extent in water. With metallic oxides it gives very fine "lakes" of varying hues, and is used in making dyestuffs. (See Madder.)

ALKALI TRADE—See Annual Reports of the Alkali Act Inspectors, published by H.M. Stationery Office, on "Alkali Works," and articles in *C.T.J.*, 1929, **85**, 172; 1930, **87**, 55; and 1931, **88**, 583.

ALKALI WASTE—The residual matter or by-product from the manufacture of sodium carbonate by the old Leblanc process. For every ton of soda ash produced there are from one and a half to two tons of waste. Many processes have been devised for the extraction or recovery of the sulphur it contains in combination with calcium—viz., 15 to 20 per cent.—and of these the most important is the "Chance" process, which, however, is applicable only to recently made waste as distinct from the old accumulated masses lying in manufacturing areas, and which rapidly suffer chemical changes by atmospheric action. (See Sodium (Carbonate) and Sulphur.)

ALKALIES—Hydroxides of the alkaline metals. (See Bases.)

ALKALIMETRY—The determination of amount of alkali contained in a solution by titration with a standard acid solution. (See Volumetric Analyses.)

ALKALINE EARTH METALS—See Bases.

ALKALOIDS—A nitrogenous class of organic substances (bases), viewed by some as built up or derived from amino-acids. They are basic or alkaline in character, and may be regarded on the whole as compound ammonia bodies, or as derived from ammonia (NH_3) by replacement of an equivalent or more of hydrogen by organic radicles and resembling ammonia, as many of them do, in forming definite or crystalline salts with acids, and in other respects. As a class they are bitter compounds of poisonous character and they are individually described under their several names.

The vegeto-alkaloids occurring in plants, in contradistinction to those derived from animal sources (such as cadaverine), constitute an important group of compounds by reason of their physiological properties, and are the active principles of many drugs. As they exist in plants they are, for the most part, in combination with acids such as citric, malic, tannic, and quinic acids, and comprise quinine and the other associated alkaloids, aconitine, atropine, berberine, brucine, codeine, coniine, hyoscyamine, matrine, morphine, nicotine, papaverine, pilocarpine, solanine, strychnine, etc. In order to obtain them, the plant parts containing them are macerated with lime or soda to liberate the free alkaloid, and then extracted with some solvent such as alcohol, benzene, or petroleum. The extract is then acidified, say, with hydrochloric acid, which separates any associated fat, leaving the alkaloid in association as hydrochloride, and the fat is extracted from the mixture by means of petroleum ether.

ALKALOIDS (*Continued*)—

In other cases they are extracted from the plant tissues by infusion with acidified water. (See "The Micro-Detection of Alkaloids," by G. Lander (*Analyst*, 1930, **55**, 474); *The Plant Alkaloids*, by T. A. Henry (J. and A. Churchill, London); "New Alkaloids Discovered, 1920-1929 Inclusive," by J. F. Couch (*Amer. J. Pharm.*, 1931, **103**, 242-251 (May)); and vol. vii., 5th edit., of Allen's *Commercial Organic Analysis* on "Vegetable Alkaloids" (J. and A. Churchill, London); also Amines and Ptomaines.)

ALKANES—Open chain hydrocarbons, such as the Paraffins. (See Hydrocarbons.)

ALKANET—An ancient dyestuff in the form of a dark red amorphous powder, prepared from the roots and leaves of the shrub *Lawsonia inermis*. It exhibits a green iridescence; is used by natives in the East for dyeing the nails, teeth, hair, and garments; also for colouring oils red.

ALKENES—Olefines. (See Hydrocarbons.)

ALKINES—Acetylenes. (See Hydrocarbons.)

ALKYL (Radicals)—The monovalent groupings (C_nH_{2n+1}), such as methyl and ethyl, which form the radicals of the monovalent alcohols.

ALKYLENES—The divalent residues (C_nH_{2n}), such as the olefines.

ALLANITE—A natural complex silicate. (See Orthite.)

ALLOPHANE—A mineral hydrated aluminium silicate of sp. gr. 1·75.

ALLOTROPY—The isometric, polymeric and polymorphic properties of assuming various distinct forms. Oxygen and ozone, for example, are allotropic forms of the same substance. Again, carbon is known in the forms of the diamond, graphite, and charcoal, while sulphur, tin, antimony, and phosphorus are respectively known in several distinct forms. Allotropy lacks a sufficiently restricted definition, but it has been conjectured that it is to be attributed to the varying number of atoms contained in the molecules of the various substances capable of assuming sundry distinct structural forms. At least, it may be stated to result from the interplay of matter and force. In cases where there is a definite temperature at above or below which the one form passes completely into the other, the allotropy is described as enantiotropic—as, for example, grey and white tin—and when one form is more stable at all temperatures than the other, the allotropy is termed monotropic, as in the case of the so-called *explosive* antimony. (See E. Cohen, *Chem. and Ind.*, 1929, **48**, 162-169.)

ALLOXAN ($C_4H_2N_2O_4$)—A derivative of uric acid, which yields urea by the action of barium hydroxide.

ALLOYS—Many metals when melted together form either mixtures or definite chemical compounds called alloys, a great number of which are very useful in the arts and manufactures. Some of these may be regarded as solutions of definite compounds in an excess of one of the metals employed, and may therefore be considered as solidified solutions.

ALLOYS (*Continued*)—

In this way, the metals aluminium, zinc, iron, tin, copper, and lead are largely used, and sometimes mercury, silver, gold, and platinum.

Some can be obtained in crystalline forms in which the combined metals are associated in atomic proportions.

The use of the microscope and the study of the thermal or pyrometric behaviour of alloys on heating and cooling afford the most important information respecting alloys, the thermal examination sufficing in many cases to determine the composition. The eutectic temperatures of alloys correspond with the cryohydric temperatures of ordinary solutions. (See Solution.)

They generally melt at temperatures lower than their components; Wood's fusible metal, for example, an alloy of lead, bismuth, tin, and cadmium melts at 60·5° C., while none of the individual components melt below 232° C. The electrical conductivity is, as a rule, lower than the mean as calculated from the component parts, since such alloys acting as thermo-couples exercise force in opposition to that producing the current.

Alloys of the solid solution class—that is, those in which the dissolved substances cannot be detected or mechanically separated—such as brass and German silver, exhibit properties like those of single metals, can be cold-rolled and drawn, and are harder than the constituent metals.

Eutectic alloys are brittle, and have melting-points lower than either of their constituent metals. (See Eutectic.)

Antifriction alloys, extensively used for bearings, are composed of tin and antimony with either copper or lead, as they combine hardness with plasticity.

The crystal structures found in pure metals become modified in alloys, particularly so in the solid-solution variety, where the atoms of the alloying element enter into the structure and produce certain minute changes, influencing their behaviour on melting, freezing, and in other phenomena.

In making alloys, the metal of highest melting-point is first fused and the others added in order of theirs.

So-called *German silver* is a mixture of copper, zinc, and nickel; and *brass* consists of about 2 parts copper and 1 part zinc.

The British gold coin consists of pure gold 22 parts and 2 parts alloy of silver and copper, and, until recently, silver coins consisted of 92½ parts silver and 7½ parts copper.

Descriptions of various alloys will be found under the headings of the metals used in compounding them, and some of the better-known ones are shown in tabulated form on the following page.

An alloy of 85 per cent. lead and 15 per cent. magnesium when exposed to moist air undergoes rapid oxidation, swelling up and falling to a black powder in course of a few hours, the interactions being expressed as follows:

$$(a)\ Mg + O + H_2O = MgO_2H_2.$$
$$(b)\ 2Pb + O + H_2O = Pb_2O_2H_2.$$

ALLOYS (*Continued*)—

This alloy decomposes water, liberating hydrogen, and particularly so when the proportion of magnesium is increased to 30 per cent.

There are alloys of nickel and chromium of high tensile and acid-resisting strength which will withstand temperatures of over 1,260° C. without oxidation and consequent scaling. Most of the commercially useful ones fall within about 10 per cent. and 50 per cent. chromium respectively. Furnace parts of such character usually contain from 25 to 35 per cent., while resistance wire is made from the binary alloy containing from 10 to 15 per cent.

Nickel-chromium-iron alloys are also extensively employed, having great heat and acid-resisting properties, the percentage of iron depending upon the magnitude of the stress they have to bear as used. The "Emperor" alloy will, it is claimed, resist a temperature of 1,750° to 1,800° F., the tensile strength remaining at 30,000 lbs., being, when cold, approximately twice that of cast iron. (See J. F. Kayser, *C.T.J.*, April 27, 1923.)

	Cadmium.	Copper.	Zinc.	Tin.	Antimony.	Nickel.	Lead.	Bismuth.
Aluminium bronze ..	—	9	1	—	—	—	—	—
Muntz metal	—	3	1	—	—	—	—	—
Yellow brass	—	66	33	—	—	—	—	—
Tin or red brass	—	82	15	3	—	—	—	—
Mosaic gold	—	50	50	—	—	—	—	—
Britannia metal (*a*) English	—	1	—	94	5	—	—	—
,, ,, (*b*) sheet	—	1·6	—	90·6	7·8	—	—	2
,, ,, (*c*) cast ..	—	0·2	—	90·6	9·2	—	—	—
Bell metal	—	80	20	—	—	—	—	—
Bronze (for statues) ..	—	91·4	5·53	1·7	—	—	1·37	—
,, (for cannon) ..	—	90·0	—	10·0	—	—	—	—
German silver	—	50	25	—	—	25	—	—
Gun metal	—	9	—	1	—	—	—	—
Type metal	—	—	—	5	20	—	75	—
Stereotype metal	—	—	—	3	18	—	112	—
Pewter (*a*)	—	—	—	4	—	—	1	—
,, (*b*)	—	1·8	—	89·4	7·0	—	1·8	—
Wood's fusible metal ..	1	—	—	1	—	—	2	4
Minofor metal	—	3·3	10	68·5	18·2	—	—	—

Other elements are also present in many of these alloys, including carbon, silicon, aluminium, manganese and copper, according to the application to be made of them.

They are not sufficiently resistant to be suitable for the construction

ALLOYS (*Continued*)—

of chemical plant required to deal with acid liquors at above or in the neighbourhood of 100° C.

The physical properties of a number of alloys used for dental applications are described by R. L. Coleman (*B.C.A.*, 1929, B, 175).

Aluminium is extensively used in making a number of alloys with copper. (See Bronzes.) *Magnolium* is an alloy of aluminium with from 2 to 30 per cent. of magnesium; silver-white, strong, ductile, easily cast, and of sp. gr. from 2 to 2·5. When 10 per cent. magnesium is present, the alloy has a melting-point of from 650° to 700° C.; is lighter than aluminium and of good workability.

Alloys of aluminium and magnesium of the compositions Al_3Mg_2 and Al_2Mg_3 have been described, and other magnesium alloys adapted to special applications are made containing small percentages of copper, manganese, nickel, lead, tin, and iron. Evidence has also been forthcoming of the existence of definite alloys of copper with zinc and tin respectively, having the formulæ $CuZn_3$ and Cu_3Sn, and others recognized as true chemical compounds include Al_3Mn, Cd_3Tl, Hg_6Na, Hg_2Na, $PtHg_2$, PtZn, PtSn, $SnCu_3$, Zn_3Hg, and AuCu.

Aluminium alloy A, which has been found to meet requirements of the motor and other industries, consists of aluminium, 87·30 per cent.; copper, 4·68 per cent.; zinc, 2·37 per cent.; nickel, 1·85 per cent.; lead, 1·51 per cent.; magnesium, 1·34 per cent.; iron, 0·51 per cent.; silicon, 0·39 per cent.; tin, 0·050 per cent.; and a trace of manganese.

A tertiary alloy of lead, with 2 per cent. barium and 1 per cent. calcium, was found during the Great War to have value as a bearing metal and, in view of the shortage of antimony, in making shrapnel bullets. Alloy steels are dealt with in particular under the heading of Iron.

Among newer alloys are "Alargan" (aluminium and silver), "Platalargan" (aluminium, silver, and platinum), and "Platnik" (platinum and nickel).

Soldering means fusing together the surfaces of the same or different metals by means of an interposed alloy which must be more fusible than the two metals to be joined, and have an affinity for both of them. Solders may be described as fusible alloys, classed respectively as "hard" or "soft" according to their m.p.s, the former comprising various brazing, silver, and gold solders, and the latter being, in the main, lead-tin alloys melting below 300° C. Hard solder, used in brazing brass, consists of equal parts of copper and zinc, while for copper and iron a mixture of 1 part copper and $\frac{3}{4}$ part zinc in used.

For brazing steel a solder of 19 parts silver with 1 part each of brass and copper is used.

Cadmium as prepared electrically is now used to a considerable extent in compounding lead-cadmium-zinc alloys for use in general soldering work; one recommended formula being Pb, 90·8 per cent.; Cd, 7·8 per cent.; and Zn, 1·4 per cent.

A solder composed of 4 per cent. Hg, 3 per cent. Sn, and 93 per cent. Pb has found favour in the U.S.A. in respect of ships' fittings, such as

ALLOYS (*Continued*)—
galvanized-iron tubes and sheets, the joints holding well when the soldered parts are bent.

The best solder for aluminium is stated to consist of a mixture of about 55 per cent. Ge and 45 per cent. Al, although its cost is prohibitive; others are listed in the *C.T.J.*, 1930, **86**, 33.

There are many factors to be considered in connection with the use of solders, such as composition, fusibility, range of temperature, solidification, hardness, etc., and various specifications are given by the B.E.S.A. (See also G. O. Hiers, *B.C.A.*, 1932, B, 187.)

Rostosky and Lüder opine that the joining power of a solder may be due to: (1) The solder and the object forming solid solutions together, such as brass solder and copper; (2) the formation of inter-metallic compounds of the solder and the object, such as tin-lead solder and copper; and (3) the solution of the object metal in the solder, while, upon cooling, the dissolved metal crystallizes out on the solder layer—*e.g.*, tin-solder and zinc. (*B.C.A.*, 1929, B, 212.)

Fluxes are used for cleaning metal surfaces. (See Fluxes.)

(See also "Alcobronze" (under Copper), "Aludur," "Aterite," "Babbitt" Metal, "Carbobronze," "Coronium," "Corronil," "Duralumin," "Durimet," Dutch Metal, "Electron," "Elinvar," "Ferro-Alloys," "Friary Metal," Fusible Metal, "Invar," Iron, "Ironac," "Magnolia," "Monel," Mosaic Gold, "Ohmal," "Pallas," "Permalloy," Phosphor Bronze, "Pinchbeck," "Platinite," "Platinoid," "Platinor" (under Platinum), Rustless Steel, Silicon Bronze, "Silumin," "Silveroid," "Speculum," "Stalloy," "Staybrite," "Stellite," and Welding.)

ALLSPICE OIL—See Pimento Oil.

ALLUVIAL ACTION—The action of water and air on rocks, attended with the consequent formation of various mineral deposits. (See Clay.)

ALLYL ALCOHOL (C_3H_5OH or $CH_2:CH.CH_2OH$)—A limpid liquid of pungent odour, b.p. 97° C., sp. gr. 0·8491; soluble in alcohol and ether, from which glycerol may be obtained by oxidation. Chemically regarded, it is a so-called unsaturated monohydric alcohol, and is prepared by processes of direct reduction from glycerol, as, for example, by the agency of formic acid. It is used in medicine and in the manufacture of poison gases.

ALMOND OIL—Bitter almond oil is extracted by maceration and distillation from the ripe seeds of *Amygdalus communis,* which is cultivated in Italy, Spain, and the south of France, thus yielding from 35·5 to 62·5 per cent. of yellowish oil of sp.gr. 1·045 to 1·060 at 15° C., and ref. ind. of 1·542. It is soluble in alcohol and ether, and is used for flavouring and scenting purposes. Its fragrant odour is due to benzaldehyde (C_7H_6O), which is not contained in the original oil, but is produced (about 90 per cent. content), together with hydrogen cyanide and a sugar named gentiobiose (structurally identical with maltose), during the maceration by action of the enzyme named emulsin

ALMOND OIL (*Continued*)—

on the amygdalin contained in the fruit, and which can also be prepared from benzyl chloride. The synthesis of amygdalin from gentiobiose has been effected by Haworth.

Sweet almond oil is obtained by expression of the same seeds, the content varying from 45·3 to 67·1 per cent. It has a yellowish colour, is aromatic, has a sp. gr. of 0·915 to 0·920, consists mainly of olein, and is used in perfumery and as a delicate lubricant. A recent analysis of this oil gives 83·73 per cent. olein, 14·77 per cent. linolein, and 1·5 per cent. glycerides of saturated acids as the composition. (See "Notes on Histology of the Almond," by V. A. Pease (*Analyst,* 1931, **56,** 187); Benzaldehyde, Glucosides, and Nitrobenzene.)

ALOES (**Bitter Aloes**)—The inspissated juice of various species of the aloe, containing aloin; used in medicine. There are many varieties, including Socotrine aloes and Zanzibar aloes (both produced in East Africa from *Aloe Perryi,* etc.), which are most highly esteemed.

Barbadoes aloes comes from the leaves of *Aloe chinensis* and *Aloe vulgaris,* and is a dark-coloured, resin-like substance; Cape aloes, from *Aloe ferox, A. africana,* and *A. spicata,* is used both in medicine and dyeing, and besides aloin and resins is stated to contain some proportion of emodin. (See *C.T.J.*, 1932, **90,** 12.)

ALOIN ($C_{16}H_{18}O_7$)—A yellow crystalline substance, named barbaloin, extracted from Barbadoes aloes, little soluble in water and alcohol, but soluble in formamide and alkalies; used in medicine. (See Gibson and Simonsen, *J.C.S.,* 1930, p. 553, and E. Léger on "The Constitution of Aloins," *B.C.A.*, 1931, A, 490.)

"ALOXITE"—See Abrasives.

ALPHA (**Beta** and **Gamma**)—Prefixes used to distinguish isomeric bodies and certain light rays. (See Naphthol—Alpha and Beta.)

ALPHA-RAYS—See Radio-Activity.

"ALUDUR"—A hardened aluminium alloy. (See Aluminium.)

ALUM (**AMMONIA**)—Trade name for Ammonium-aluminium-sulphate.

ALUM (**CHROME**), or **Potassium Chromium Alum** ($K_2SO_4,Cr_2(SO_4)_3 24H_2O$), is prepared by the addition of sulphuric acid to potassium dichromate ($K_2Cr_2O_7$) dissolved in water, and then reducing it by the passage of sulphur dioxide gas, with the result that the two sulphates of potassium and chromium are left in solution, from which the alum can be crystallized out in the form of dark plum-coloured octahedral crystals. It is used in paper making, sugar refining, ink making, as a chrome-tanning material, and in the textile industry as a mordant, etc.

ALUM (**IRON**)—See Iron.

ALUM SHALE—See Aluminium.

ALUMINIUM (Al) **and its Compounds** (atomic weight 26·97; sp. gr. 2·7; m.p., 658·7° C.)—Aluminium is a trivalent metal found very abundantly in nature in a state of combination, but not in the metallic state.

ALUMINIUM (*Continued*)—

It occurs as a phosphate in *wavellite,* and combined with oxygen as alumina (Al_2O_3), it forms the substance of *emery* and, in purer forms, the precious stones known as the *sapphire* and *ruby,* both of which are now produced commercially by the fusion of pure alumina in a specially constructed electric furnace, and are as good in all respects as the natural gems, with which they are identical in composition and properties.

In combination with silica, aluminium exists as *allophane,* clays, and *leucite,* and in the forms of *gibbsite* ($Al_2O_3,3H_2O$), *diaspore* (Al_2O_3,H_2O) and *bauxite* ($Al_2O_32H_2O$) as a hydrated oxide, from which last-named mineral the metal is chiefly manufactured by an electrical process. (See also Fluellite.)

Bauxite occurs in large deposits in many of the American States, France, Iceland, Calabria, Styria, the Gold Coast Colony, India, British Guiana, Montenegro, etc., and the Narracan deposit found in Victoria (Australia) has an alumina content of 52 to 59 per cent. The output in the U.S.A. in 1923 was 522,690 long tons, and the industry in British Guiana is considerable.

Leucite can be utilized by a variety of processes as a source of alumina, potash, and silica. (See *J.S.C.I.*, xliv., B, 240; also Leucite.)

There are several varieties of bauxite—viz., a white quality containing some 60 per cent. alumina, a little iron, and no silica, which is used for making aluminium salts and alum; a red variety of about the same alumina content, but containing little silica, used for manufacturing metallic aluminium; and another white kind containing only 45 per cent. alumina and much silica, which is used more for making refractories. Sodium sulphide has so far proved to be the most effective agent for conditioning the pulp in experiments on the gestation of bauxite high in silica content. As a colloidal absorbent acting as a decolourizer and desulphurizing agent bauxite is used for purifying mineral oil by filtration. (See *The Industrial Uses of Bauxite,* by N. V. S. Knibbs (Ernest Benn, Ltd., London).)

To prepare metallic aluminium, alumina made from bauxite and dissolved in fused *cryolite*—a double fluoride of aluminium and sodium (Na_3AlF_6)—is subjected to electrolysis in iron pots lined with carbon, carbon rods being used to carry the current; the power used for generating the electric current (by dynamos) being that of falling waters as utilized at Niagara, the falls of the Rhine at Schaffhausen, and Kinlochleven in Argyllshire. In this way, the aluminium oxide is decomposed, the melted metal collects at the bottom of the pots and oxygen is liberated at the carbon poles. Cryolite is, so far, only found in abundance in Greenland, so it is said to be (generally speaking) cheaper to synthesize from calcium fluoride, of which there are large natural supplies.

The metal can also be obtained from clay or alunite by a process commencing with ignition, then resolution into sulphate by means of sulphuric acid, followed by conversion into ammonia alum by addition of ammonium sulphate, and by action of dry ammonia gas at 75° C.

ALUMINIUM (*Continued*)—

conversion into aluminium hydroxide and ammonium sulphate. The hydroxide is then ignited, forming alumina, from which the metal is made. Various processes proposed and in use for refining aluminous ores are reviewed by C. L. Mantel. (See *B.C.A.*, 1929, B, 132.)

Aluminium of improved physical properties imparted by a secret mechanical method is now produced in Germany under the name of *Aludur*. It exhibits a "Brinell hardness" of number 80, a high ductility, resistance to shock and corrosion, and good electrical conductivity.

The "Hooper" electrolytic refining process, by which aluminium of average purity 99·80 per cent. is obtained, is described by F. C. Frary in a condensed report (*C.T.J.*, 1925, **76,** 665). The metal thus produced is much softer than the ordinary metal, holds its lustre better, and is much more resistant to acids. The process consists in electrolyzing a molten copper-aluminium alloy, low in iron and titanium content, below a fused bath of a mixture of cryolite, aluminium fluoride, and barium fluoride nearly saturated with alumina.

The total annual output of aluminium is now estimated at more than 200,000 tons, the U.S.A. producing some 90,000 per annum, while in 1927 five works in Norway were turning out 24,000 tons per annum.

The metal is extremely light, being about one-third the weight of iron, and is of the colour of tin. It is very malleable, ductile, does not tarnish when exposed to dry air, although it is subject to surface oxidation in moist air, particularly in hot climates. It is a good conductor of electricity, and is extensively used in the construction of many articles both for manufacturing and household employment, storing spirituous liquors, milk, etc. Exposure to a high temperature and repeated remelting is stated to bring about a deterioration in the character of aluminium. The metal is now largely used in making chemical plant, being stable against essential oils and ammonia (of all strengths and at all temperatures), and when quite pure it can be employed in respect of nitric acid. Aluminium is also used in the construction of zeppelins, and alloyed with various other metals it can be usefully employed where lightness combined with strength are desirable qualities. It is now prepared in standardized sheets of various thickness for the making of cans suitable for the preservation of foods and other purposes. In the form of powder it finds use as an ingredient of certain explosives (see Ammonal) and in the "thermite process," while it is largely employed in the metallurgy of other metals. As solder for aluminium, various compositions of zinc-tin and zinc-tin and aluminium are stated to give the best results. It is not proof against hot acetic acid in dilute solutions or barium chloride, and must be ruled out in respect of hot solutions of tartaric acid, ferro- and ferri-cyanides. (See *C.T.J.*, 1928, **82,** 649.) The solvent action of washing soda on aluminium utensils is said to be entirely prevented by addition of a small amount of "water-glass" to the washing water (as little as 0·05 per cent.).

Aluminium powder is largely used in making fireworks, paints, and

ALUMINIUM (*Continued*)—

explosives, also mixed with oil as a paint for iron exposed to the air. Its manufacturing problems are subject of an article (*C.T.J.*, 1930, **86**, 428).

An alloy with 2 per cent. manganese is more resistant to corrosion than commercial aluminium (H. Wolf, *B.C.A.*, 1932, B, 186).

In combination with copper, it forms an alloy known as *aluminium bronze*, which makes good castings. This is manufactured by heating a mixture of alumina in the form of *corundum* with charcoal and granulated copper in an electric furnace, in which process the carbon is burned out of the mixture by the oxygen of the alumina (Al_2O_3), and the copper combines with the metallic aluminium.

The compound Al_3As_2 is produced when a mixture of aluminium and arsenic is heated to about 750° under a low pressure.

An alloy of 85 per cent. aluminium, 12·5 per cent. zinc, and 2·5 per cent. copper has proved very successful for general castings, crank cases, pump-bodies, carburettors, etc. (See *C.T.J.*, 1927, **80**, 272; N. Bugden on "Aluminium Casting Alloys," *Ind. Chem.*, 1930, vi., 117; *Analyst*, 1931, **56**, 664; and Alloys.)

A 15 per cent. aluminium-iron alloy is made in Germany for making articles highly resistant to heat, as on heating to redness a thin, highly resisting layer of aluminium oxide is produced on the surface which does not scale, and prevents further oxidation.

Methods of coating aluminium articles dead-white, using milk of lime or strontium hydroxide, by non-electrolytic processes, are referred to in the *C.T.J.*, 1929, **85**, 294. (See also W. H. Mutchler (*B.C.A.*, 1932, B, 187); "Some Aspects of the Uses of Fabricated Aluminium in the Chemical Industry," by S. J. Ralph (*Ind. Chem.*, 1930, vi., 459); book on the metallurgy and applications of aluminium by R. J. Anderson (H. Carey Baird and Co., of New York); and Aluminium Bronzes, p. 40.)

Aluminium Oxide or **Alumina** (Al_2O_3) and the hydroxide ($Al_2O_3.3H_2O$) are used as mordants in dyeing and calico printing owing to their property of forming insoluble compounds known as "lakes" with vegetable colours, thus fixing them in the tissues undergoing treatment and making them washable or "fast." The hydroxide can be prepared by adding ammonia to a solution of alum, as a white precipitate, which can be rendered anhydrous by drying and heating. Another variety ($Al_2O_3,4H_2O$) apparently exists. (See *J.C.S.*, 1927, p. 1223.)

A special activated alumina being a partially dehydrated trihydrate in the form of hard porous masses, is now being marketed in the U.S.A. It possesses stability, purity, large surface area, and great absorptive power, and is recommended for use in drying operations, as a dehydrating catalyst, and the removal of chlorine from hydrogen and hydrogen sulphide from carbon dioxide, etc.

A dry process for the preparation of alumina involves furnacing bauxite (which must contain less than 3 per cent. of free silica) with soda, and subsequent extraction of the sodium aluminate by leaching with water, and there is a wet process in which the mineral is first

ALUMINIUM (*Continued*)—

heated under pressure with a solution of caustic soda. From these solutions the alumina is obtained by two distinct methods. In the one, carbon dioxide gas is blown into the solution, thus precipitating the hydroxide, and in the other the solution, after dilution, is stirred with a small quantity of hydrated alumina, in which case a large proportion of the alumina in solution is precipitated, leaving a liquid which, after concentration, is used for attacking a fresh quantity of bauxite.

In another process (known as the "Serpek," or "nitride") bauxite, carbon (coal), and nitrogen are made to inter-react at a high temperature (1,700° to 1,800° C.), and the aluminium nitride thus produced yields sodium aluminate upon treatment with sodium hydroxide, ammonia being incidentally obtained as a by-product. From this, pure alumina can be readily produced ready for the application of the electrical process for producing the metal.

A process is used in Norway for producing alumina from bauxite, by leaching with a 30 per cent. nitric acid solution, which dissolves the aluminium, calcium, and part of the iron contents, leaving the silica and the rest of the iron undissolved. The iron in solution is then removed, the liquid evaporated to dryness, and the residue heated to such an extent that the aluminium salt only is decomposed. The nitrogen oxides driven off in this operation are recovered as nitric acid, and the alumina is employed for the manufacture of the metal and its various compounds.

The "Hagland" electro-thermic process for making pure oxide depends upon the removal of the bauxite impurities—iron oxide, silica, etc.—by reduction with carbon in an electric furnace, and the production thereby of a slag containing 15 to 20 per cent. of sulphide. This sulphide-oxide slag is fluid, and after cooling is crushed and treated with water, by which it is decomposed as shown by $Al_2S_3 + 6H_2O = 2Al(OH)_3 + 3H_2S$, the hydrogen sulphide being utilized for sulphurizing the bauxite or for making sulphur by the Claus process. (See *Ind. Eng. Chem.*, January 7, 1926.)

Another new method (Pederson's) depends upon the reduction of bauxite to aluminium oxide by means of iron ore instead of coal, crude iron being obtained as a by-product.

(See also Clays and Emery.)

Corundum, a nearly pure natural oxide of aluminium of density 3·9 to 4·1 occurs in crystallized form No. 3, hard enough to cut glass; it is now made by an electrical process on a considerable scale, and is largely used for polishing purposes. An account of its manufacture is given by R. Schniedler. (*B.C.A.*, 1930, B, 948.)

Anhydrous alumina (Al_2O_3) is made by calcination of the hydroxide.

Aluminium Chloride ($AlCl_3$) is a white, volatile, solid substance produced by heating powdered metallic aluminium, or a mixture of alumina and charcoal, in a current of chlorine. The "McAfee" process for its cheap production from bauxite by means of chlorine is described in the *Ind. Chem.*, 1929, v., 391, in an article reproduced

ALUMINIUM (*Continued*)—

from the *Chem. and Met. Eng.* of July, 1929, p. 422. (See also *C.T.J.*, 1929, **85,** 51; *Chem. and Ind.*, 1929, **48,** 836; M. Naphtali, *B.C.A.*, 1930, B, 186, and C. Wurster, *ibid.*, B, 1026.) Bauxite ore is briquetted with good coking coal and the briquettes then heated to about 1,500° F. to get rid of hydrocarbons, after which the resulting carbonized briquettes are chlorinated at about 1,600° F. The product is pure enough for use in the petroleum-cracking industry, for which the bulk of it is used, but for synthetic organic processes based upon the Friedel and Craft reaction and other purposes, a purified form would appear to be desirable or necessary. (See K. Bodendorf, *B.C.A.*, 1931, A, 582.) It is marketed in liquid, crystal, and anhydrous forms, and used variously in carbonizing wool and as a catalytic agent. The crystalline hydrated salt is $AlCl_3.6H_2O$, and both are soluble in water and alcohol.

Aluminium Sulphate ($Al_2(SO_4)_3 18H_2O$) constitutes the natural minerals *aluminite* (a basic salt of the composition $Al_2O_3.SO_3 9H_2O$) and the fibrous *hair-salt*. Large quantities are manufactured by dissolving the mineral *bauxite* in sulphuric acid and purifying the product from associated iron impurities which would interfere with its applications in the calico-printing, tanning, waterproofing, dyeing, paper-making, water purification and other industries. It is colourless, crystalline, soluble in water and marketed in lumps, nuts, peas and rice sizes, also large slabs.

Its use constitutes an effective and inexpensive method of changing the neutral or alkaline reaction of ordinary soil to one of acidity, and a solution of it can be used for rendering concrete floors dustless.

A descriptive article on its manufacture will be found in the *C.T.J.*, December 5, 1924, and reference to its uses in "Plant Construction." *Ind. Chem.*, iv., 79).

Aluminium Nitrate ($Al(NO_3)_3$), in anhydrous and hydrated forms, is a white crystalline body, soluble in water, used in the textile and leather industries.

Alums are double sulphates, the most important of which is the so-called potash alum or ordinary alum of commerce, and they are all soluble in water. This aluminium potassium sulphate ($Al_2(SO_4)_3 K_2SO_4,24H_2O$) is a colourless, crystalline, efflorescent salt, made on a large scale by mixing the two sulphates and allowing the compound to crystallize out of solution. In a form known as "Roman alum" it is also prepared by dissolving calcined *alumstone* (*alunite*) in water, which leaves alumina undissolved; or calcined *alumstone* can be dissolved in sulphuric acid, and the solution admixed with the proper proportion of potassium sulphate and then subjected to crystallization.

There is a further process by which it can be produced from a bituminous mineral known as *alum shale,* consisting mainly of aluminium silicate with iron pyrites distributed throughout. This shale, when roasted and subsequently exposed to air and moisture, suffices to

ALUMINIUM (*Continued*)—

oxidize the pyrites and to form sulphuric acid, thus producing aluminium sulphate, the iron being converted into ferrous and ferric sulphates and ferric oxide, and then, when the product is lixiviated with water, the resulting solution, after addition of the requisite quantity of potassium sulphate or chloride, yields the so-called alum meal upon concentration and crystallization.

Alum is extensively used in the dyeing and calico-printing industries. It is readily soluble in water, and when heated in the dry state melts in its own water of crystallization, which is gradually expelled by heating, and when the process is carried to a dull red heat a white porous mass of so-called *burnt alum* is left.

Ammonia alum or aluminium-ammonium sulphate contains ammonium in place of the potassium of ordinary alum, and is manufactured on a considerable scale, using ammonia (as prepared in gas-works) and sulphuric acid in conjunction with the burnt alum shale already referred to. This shale contains iron pyrites (FeS_2), and when roasted in air, the sulphur is to some extent oxidized to sulphuric acid, which combines with the alumina.

Soda alum ($Al_2Na_2(SO_4)_4,24H_2O$) is a crystalline soluble salt used as a mordant, also in water purification as a precipitant, and in the paper industry.

Aluminic Acetate ($Al_2(C_2H_3O_2)_3$), or so-called "red liquor," in aqueous solution is used as a mordant in calico printing and dyeing, also for waterproofing cloth, etc.

The borate ($2Al_2O_3.B_2O_3.H_2O$), a white soluble salt used in making glass and ceramics; the fluoride ($Al_2F_6,7H_2O$) with small amounts of sulphuric acid for moth-proofing woollen goods; and the phosphate ($AlPO_4$) (an insoluble compound) used in ceramics.

Aluminium resinate, when freshly prepared by heating aluminium hydroxide and rosin, is soluble in ether, benzene, and carbon tetrachloride, and is used in the sizing of paper.

The stearate ($Al(C_{18}H_{35}O_2)_3$ is extensively used in the oil and paint trades for thickening and increasing the viscosity of oils in which it is dissolved. Its use prevents "settling" in ready-mixed paints and produces a flatting effect. (See *C.T.J.*, 1930, **87**, 373.)

Aluminium Silicates—See Clays, Kaolins, and Sillimanite.

ALUMINIUM BRONZES—One consists of 9 parts copper and 1 part zinc, resembling gold in appearance; of sp. gr. 7·69 and not easily tarnished by the air. Others contain 3, 5, and up to 10 per cent. aluminium. (See Bronzes.)

ALUMINITE—See Aluminium Sulphate.

"**ALUMINO-FERRIC**"—A proprietary mixture of crude sulphates of iron and aluminium used as a precipitating and clarifying agent in the treatment of sewage and refuse liquids.

ALUMS—See p. 39.

"ALUNDUM"—See Abrasives.

ALUNITE or **ALUMSTONE**—A natural, greyish, hydrated basic potassium alum ($Al_2(SO_4)_3,K_2SO_4,2Al_2O_3,8H_2O$), of sp. gr. 2·83, found at Tolfa and elsewhere in Italy, also in Utah, where it is roasted to make sulphuric acid and yield alumina and potash. The calcined mineral, upon lixiviation with water, dissolves the potassium alum, leaving the other alumina undissolved.

ALVA—See Esparto Grass.

ALVA MARINA—A prepared seaweed used in upholstery for stuffing.

"ALVESCO"—A fumigating preparation for the disinfection of plant houses; it generates a blend of toxic vapours, one of which is a chlorinated nitro-compound particularly destructive of red spider and white fly.

Am—A prefix sometimes used for amyl (C_5H_{11}).

AMALGAMS—The name given to combinations of other metals with mercury. Gold and lead, for example, are both somewhat easily dissolved by liquid mercury in varying proportions, and while, in all probability, some of these products are definite compounds, most such combinations are probably mere mixtures or solutions. The potassium and sodium amalgams decompose water, with evolution of hydrogen, and are frequently used as reducing agents. Amalgams composed of 25 per cent. zinc, 25 per cent. tin, and 50 per cent. mercury, as also amalgams of cadmium and cadmium-tin, are used as dental cements, and the first-named one in the construction of electrical machines. Amalgams of gold and copper are also used by dentists as stoppings for teeth, and tin amalgam is employed for silvering mirrors. Of the silver-tin alloys, Ag_3Sn is stated to take up the maximum amount of mercury. There is a native amalgam of mercury and silver in which the proportion of silver ranges from 27·5 to 95·8 per cent., and a native gold amalgam containing from 39 to 42·6 per cent. is found in California and Colorado. (See Sodium Compounds, p. 835.)

AMATOL—See Explosives.

AMBER (**Succinite** and **Gedanite**) ($C_{10}H_8O$)—The composition of the two forms, succinite and gedanite, is very similar. It is a yellow, resin-like, combustible substance of probably vegetable origin, found upon some sea-shores, including the Prussian coast, and as a fossil from the extinct conifer *Pinus succinifer* (Goppert) in certain alluvial soils, but Germany possesses the most commercially profitable deposits. Its usual position is in beds of brown coal formation of lower Tertiary Age. It becomes electrified by friction, and shows a strong fluorescence when illuminated by ultra-violet light. It finds use in the construction of pipe mouthpieces, the bowls of Turkish pipes, and amber necklaces; also used to some extent in the preparation of amber varnishes and amber spirit-varnishes. It contains from 3 to 4 per cent. succinic acid; yields by destructive distillation so-called amber oil, of b.p. 130° to 140° C.; sp. gr. from 9·15 to 9·75; containing some

AMBER (**Succinite** and **Gedanite**) (*Continued*)—

terpenes, but consisting mainly of phenols, and is used in varnish making. T. T. Cocking has recently given new values to the genuine oil of amber as distinct from oils obtained from other resins (*Analyst*, 1931, **56**, 200).

Clear moulded amber has recently been used for making containers for hydrofluoric acid and strong solutions of potassium hydroxide, also as a material for making resistant beakers, dishes, and other chemical apparatus. (See A. Eisenack, *B.C.A.*, 1930, A, 1549.)

By condensing cresol and formaldehyde in presence of hydrochloric acid, drying the product, treatment with sulphur chloride, and heating to 200° C., M. Samuel has obtained a material similar to amber in insulating properties. This so-called "artificial amber" of the synthetic resin type exhibits the electro-magnetic property, but can be distinguished from the natural product by the stain left on it after evaporation of a little ether dropped upon it.

AMBERGRIS—A wax-like organic substance of sp. gr. 0·908 to 0·920, varying in colour from black to white, found as a calculus in the intestinal tract of the sperm whale, consisting of a number of glycerides of highly complex fatty acids. Lumps of it are not infrequently found floating in the sea. It assumes an ointment-like character at 60° C., melts at a higher temperature, and at 100° C. volatilizes as a white vapour. It is soluble in alcohol, oils, and alkalies, and when purified is greatly valued by perfumers on account of its fine musk-like scent. The different varieties of ambergris are described by F. R. Morrison (*B.C.A.*, 1930, B, 793). (See also Cuttle-fish.)

"AMBEROL" (RESINS)—See "Albertol."

AMETHYST—A native form of silica of sp. gr. 2·5 to 2·8 and crystal system, No. 3, coloured with iron and other metallic oxides.

AMIDES (**Acid**)—Organic compounds derived from ammonia by replacement of one or all hydrogen atoms by radicals.

Acid amides result from the introduction of the amido group (NH_2) in place of the hydroxyl radical of the carboxylic group, thus: $CH_3CO.OH$ (acetic acid)$\longrightarrow CH_3.CO.NH_2$ (acetamide).

Urea or carbamide (CH_4N_2O or $CO(NH_2)_2$ is the amide of carbonic acid, and is prepared by heating ammonium carbamate to 135° C., thus:

$$\left.\begin{matrix}NH_2\\NH_4O\end{matrix}\right\}CO = CO(NH_2)_2\ \text{(urea)} + H_2O\ \text{(water)}.$$

Acetamide (C_2H_5NO or $CH_3.CO.NH_2$) is a colourless, crystalline, deliquescent body derived from acetic acid; soluble in water and alcohol, m.p. 82° C.

Benzamide ($C_6H_5.CO.NH_2$) is a crystalline substance prepared from benzoyl chloride and ammonia; soluble in hot water and alcohol, with a m.p. of 130° C.

Formamide or **Methane-amide** (CH_3NO), a colourless, oily liquid,

AMIDES (*Continued*)—

soluble in water and alcohol, and of sp. gr. 1·146; may be formulated as HCO,NH_2, being derived from HCO.HO or CH_2O_2 (formic acid), and when heated quickly splits up into carbon monoxide and ammonia. (See G. F. Smith on its purification and physical constants (*J.C.S.*, 1931, p. 3257).)

Succinamide ($C_4H_8N_2O_2$ or $C_2H_4(CO)_2(NH_2)_2$) is produced by the interaction of ammonia and ethyl succinate.

Oxamide ($C_2H_4N_2O_2$ or $NH_2.CO.CO.NH_2$), the normal amide of oxalic acid, is a white crystalline body obtainable by distillation of ammonium oxalate or by adding ammonia to ethyl oxalate.

(See Amines and Imides.)

AMIDO—See Amino.

AMIDOL—a salt of 2:4 diamino-phenol—viz., the hydrochloride ($C_6H_3(OH)(NH_2)_22HCl$)—is made by interaction of diamino-phenol and hydrochloric acid. It is a grey-white crystalline salt soluble in water, and is used with sodium sulphite as a photographic developing agent. (See Diamino-phenol.)

AMIDOPYRIN (**Dimethylaminoantipyrine**).—A white powder, m.p. 108° C., soluble 1 in 9 of water and 1 in 2 of alcohol of 90 per cent.; used in medicine. It is prepared by addition of potassium or sodium nitrite to a concentrated solution of antipyrin in dilute acetic acid, followed by reduction with zinc dust and acetic acid in alcoholic solution to amido-antipyrin; the last-named substance is then methylated by use of methyl iodide dissolved in methyl alcohol in the presence of caustic potash.

AMINES (**Nitrogen** or **Ammonia Bases of the Alkyl Radicals**)—Substances derived from ammonia containing the group NH_2, but distinct from the so-called acid amides. They constitute an important class of chemical bodies intimately connected with the alkaloidal bases or alkaloids. They have a more or less ammoniacal odour, produce white clouds with acid vapour as does ammonia, and combine with hydrochloric and other acids to form salts. Like many of the alkaloids, they yield double platinum chlorides. They are divided or classified into a number of groups—primary, secondary, quarternary, and tertiary—according to the number of hydrogen atoms replaced. The "primary" includes methylamine and ethylamine, which are respectively produced by heating methyl and ethyl cyanates with potash solution, etc. When they contain different radicals, as, for example, methyl propylamine ($NH(CH_3)(C_3H_7)$, they are described as *mixed*.

Methylamine (CH_5N or $CH_3.NH_2$) is found amongst the gaseous products of bone distillation and many decompositions of alkaloidal bodies by barium hydrate. It is strongly basic, very soluble in water, and possesses a mixed ammoniacal and fish-like odour; b.p. −6° C.

Trimethylamine $[(CH_3)_3N]$ (sp. gr. 0·662) is found in nature in several plants and well known as a constituent of herring brine. It can be obtained as a colourless liquefied gas of fishy ammoniacal odour, soluble in water, alcohol, and ether, and can be prepared by the inter-

AMINES (**Nitrogen** or **Ammonia Bases**) (*Continued*)—

action of methyl iodide and ammonia. It is met with in commerce in solutions of 10 and 33 per cent. strength respectively.

The table below shows the relationship between the primary amines:

Name.	Formula.	Boiling-point.
Methylamine	$CH_3.NH_2$	Below 0° C.
Ethylamine	$C_2H_5.NH_2$	18·7° C.
Propylamine	$C_3H_7.NH_2$	49·7° C.
Butylamine	$C_4H_9.NH_2$	69·0° C.
Octylamine	$C_5H_{11}.NH_2$	180·0° C.

The secondary and tertiary amines corresponding to the above and their relationships are illustrated by the following table:

Name.	Formula.	Boiling-point.
Dimethylamine	$CH_3.CH_3.NH$	8·5° C.
Diethylamine	$C_2H_5.C_2H_5.NH$	57·5° C.
Trimethylamine	$CH_3.CH_3.CH_3.N$	4° C.
Triethylamine	$C_2H_5.C_2H_5.C_2H_5.N$	96° C.

Another distinct class of bodies, yet with some chemical relationship, are now known as aromatic amines or *Arylamines*, of which aniline ($C_6H_5.NH_2$) is the best-known member, being regarded as benzene (C_6H_6), in which a hydrogen atom has been replaced by the amino (NH_2) group; or otherwise as ammonia NH_3, in which one of the hydrogen atoms has been replaced by phenyl (C_6H_5). Upon this latter view it is sometimes called phenylamine.

AMINO—A prefix indicative of the presence of an amino group (NH_2) in compounds. (See Amines, Amines and Amino-Acids.)

AMINO-ACETIC ACID—See Glycine.

AMINO-ACIDS—A class of substances derived from fatty acids by the exchange of an amino group (NH_2) for a hydrogen atom in the hydrocarbon radical. For example, acetic acid ($CH_3.CO_2H$) becomes $CH_2(NH_2).CO_2H$ (amino-acetic acid). This compound is also known as glycine and glycocoll (see Glycine). Amino-acids are the final hydrolytic products of the proteins, and, amongst these, one named *tryptophane* is of peculiar interest, as a supply of this substance in food has been shown to be necessary by certain experiments made on animals. According to Dr. Breese Jones, of the U.S.A. Agriculture Department, four of the eighteen amino-acids making up the various proteins are indispensable for normal nutrition—viz., lysine, tryptophane, cystine, and histidine. Other members of this group are named arginine, alanine, glycine, leucine. (See "The Biochemistry of the Amino-Acids," by Mitchell and Hamilton, American Chem. Society, Monograph Series, Chem. Catalog Co., Inc., N.Y.; also Proteins, Polypeptides, Ptomaines, Vitamins, and Foods.)

AMINO-AZO-BENZENE ($NH_2.C_6H_4.N:N.C_6H_5$)—The parent substance of the chrysoidines (dyes).

AMINO-BENZOIC ACIDS—The *m* acid ($NH_2.C_6H_4.CO_2H$) is a yellow crystalline salt (m.p. 174° C.), soluble in water; used in the dye and perfume industries. The acids of this group are amphoteric. (See Anthranilic Acid.)

AMINO-PHENOLS—These are obtained by reduction of nitro-phenols, and are more or less unstable, but their hydrochlorides are much more stable. The ortho-, meta-, and para- varieties of amino-phenol ($C_6H_4(NH_2)OH$) are white crystalline bodies soluble in water, alcohol, and ether, and are used in the dyestuffs industry. The para-variety is also used as a photographic developer.

AMMETER—See Electricity.

AMMINES—Metal-ammonium compounds, such as the compound cobalt-ammonium and copper-ammonium salts. Some of these compounds are very complex—for example, Erdmann's salt (ammonium tetranitrodiammine cobaltiate). (See vol. x., "The Metal-Ammines" of *Sutherland's Inorganic Chemistry,* Charles Griffin and Co., Ltd., London, and Platinammines and Platinum Compounds.)

AMMONAL—See Explosives.

AMMONIA—See Nitrogen (p. 612) and Nitrogen Fixation.

AMMONIACUM GUM—See Gums and Resins.

AMMONIA-OLEIN—See Turkey-red Oil.

AMMONIA-SODA PROCESS—See Sodium (Carbonate).

AMMONIA-STILL EFFLUENT—The objectionable properties of this by-product from gas-works (using horizontal retorts), in which phenol and thiocyanates participate, can be removed to a large extent by blowing the liquors with boiler-fire gases, but the phenol content is thus lost. There is, however, a process for recovering this constituent by trickling the liquor through a filter-bed of acid resin into a closed receiver, wherein it is agitated with benzene, which removes the phenol, and upon treatment of the solvent with dilute caustic soda the phenol is removed and recovered from the soda solution by acidification. When, however, the effluent liquors are derived from coal carbonized in vertical retorts the difficulties of treatment are greater, the liquors being so much more noxious owing to the presence therein of polyhydric phenols which are not volatile in steam. From experiments that have been made it would appear practicable to deal more or less efficiently with these effluent liquors by bacterial filtration where sufficient ground space is available. The treatment of spent liquors derived from coke ovens by the so-termed "activated carbon process" has been described in papers by T. Lewis Bailey and D. W. Parkes (*Chem. and Ind.*, 1925, **44,** 835; and *J.S.C.I.*, 1927, **46,** 186 T and 288 T); D. W. Parkes (*J.S.C.I.*, 1929, **48,** 81 T; *Ind. Chem.*, 1930, vi., 327); and F. Schuster (*B.C.A.*, 1931, B, 791).

AMMONIUM and its Compounds—See Nitrogen Compounds.

AMMONIUM CARBAMATE—See Nitrogen Compounds and Urea.

AMORPHOUS—Without crystalline form.

AMPÈRE—See Electricity.

AMPHIBOLE (Uralite)—There are a great number of rock-forming members of the Amphibole group, including Tremolite, Glaucophane, Hornblendes, etc. (See Asbestos and Hornblende.)

AMPHOTERIC—Amphoteric compounds are partly of one nature and partly of the other, so that they exhibit the qualification of acting—*e.g.*, either in the acid or basic capacity; thus, aluminium hydroxide dissolves in acids forming salts and in strong basic solutions forming aluminates: $Al(OH)_3 + 3HCl = AlCl_3 + 3H_2O$ and $Al(OH)_3 + 3NaHO = Al(ONa)_3 + 3H_2O$).

AMYGDALIN—See Glucosides and Almond Oil.

AMYLACEOUS—See Gums, Starches, and Cellulose.

AMYLASES—Enzyme constituent of grain. See Baker and Hulton on "Amylases of the Cereal Grains—Oats" (*J.C.S.*, 1929, p. 1655); also Beer, Diastase, Enzymes, and Starch.

AMYL ACETATE ($C_7H_{14}O_2$ or $CH_3.CO.O.C_5H_{11}$)—An alcoholic solution of this ester forms the "essence of pears." It is produced by the slow action of acetic acid upon amyl alcohol, and is made by distilling potassium acetate or lead acetate in admixture with amyl alcohol and strong sulphuric acid. There is also a process for its production from that fraction of petrol of b.p. between 25° and 45° C., the pentane content being chlorinated and the product heated with sodium acetate under pressure at 195° to 200° C. Its manufacture from pentane isolated from natural gas is described in *C.T.J.*, 1927, **80,** 417; see also *Ibid.*, 1931, **88,** 485; *Ind. Chem.*, 1927, iii., 230; and H.S. Garlick, *Ibid.*, 1928, iv., 363.

It is prepared commercially to various specifications having flash-points ranging from 73° to 120° F. It is a colourless liquid, of sp. gr. 0·866, and b.p. 148° C., nearly insoluble in water, of ethereal aromatic odour, and is largely used for flavouring purposes; as a solvent of cellulose and cellulose nitrate, also in waterproofing processes, perfumery, preparation of lacquers, etc.

AMYL ALCOHOL—See Alcohols and Fusel Oil.

AMYL BUTYRATE ($C_4H_7O_2C_5H_{11}$)—A colourless liquid ester of sp. gr. 0·859, and b.p. about 154° C., prepared by distillation of a mixture of amyl alcohol and butyric acid after addition of sulphuric acid; used as a flavouring principle, and in the making of liqueurs. (See Perfumes.)

AMYL CINNAMIC ALDEHYDE—See Jasmine Oil.

AMYL FORMATE ($CH_2OC_5H_{11}$) is a colourless liquid ester of b.p. 130·4° C., and sp. gr. 0·9018, soluble in alcohol and ether, used for flavouring; prepared in a corresponding manner to amyl butyrate from formic acid.

AMYL NITRITE ($C_5H_{11}O.NO$)—A yellowish liquid ester, soluble in alcohol and ether, of sp. gr. at 15° C. of from 0·870 to 0·880, b.p. 96° C.; used as a stimulant inhalant in cases of *angina pectoris;* also in perfumery and making fruit essences. It is prepared by distillation from a mixture of amyl alcohol and sodium nitrate to which sulphuric acid has been added.

AMYL SALICYLATE ($C_7H_5O_3 : C_5H_{11}$)—A colourless or slightly yellow liquid ester of sp. gr. 1·045, and b.p. about 270° C., prepared from amyl alcohol and salicylic acid in a similar way to that of the butyrate; soluble in alcohol and ether, and used in perfumery and for flavouring.

AMYL VALERIATE (**Apple Oil**) ($C_4H_9CO_2,C_5H_{11}$)—Prepared from amyl alcohol and valeric acid in a similar way to that of the butyrate; sp. gr. 0·8812 and b.p. 203·7° C.; is also used as a flavouring body.

AMYLENE (**"Pental"** or **Trimethylethylene,** C_5H_{10} or $(CH_3)_2.C:CH.CH_3$) is a colourless, mobile, inflammable liquid of b.p. 35° C. and sp. gr. 0·666, soluble in alcohol and ether, produced from ordinary amyl alcohol by the action of zinc. A great number of isomeric amylenes are known, "pental" being one form. (See Hydrocarbons.)

AMYLO—Concerning starch.

AMYLO PROCESS—See Alcohols.

AMYLOPSIN, otherwise known as pancreatic diastase, is one of the enzymes contained in pancreatine, capable of converting starch into dextrin and maltose. It acts best in neutral or slightly alkaline media at a temperature of between 30° and 45° C., and is destroyed at 65° C.

AMYLOSE—A polysaccharide of the starch group. (See J. Effront, *B.C.A.*, 1930, A, 895), Carbohydrates and Starch.)

AMYLUM—See Carbohydrates and Starch.

ANALCIME—A zeolitic mineral of constitution ($Al_2O_3,3SiO_2,+Na_2O,SiO_2+2H_2O$), of crystal system, No. 1, and sp. gr. 2·22.

ANALOGOUS—Having resemblance or relation.

ANALYSIS—The decomposition of substances into their essential parts or elements; or processes conducted in order to ascertain their composition or constitution qualitatively and quantitatively. (See *Recent Advances in Analytical Chemistry,* by C. A. Mitchell (J. and A. Churchill, London); Inorganic Chemistry, Nephelometry, Organic Analyses, Qualitative Analyses, Quantitative Analyses, Technical Methods, Volumetric Analyses, and the various publications to which references are made under these headings and others such as drugs, metallurgy, etc.)

ANASTASE (**Anatase**)—Mineral titanium oxide (TiO_2), of crystal system, No. 2, and sp. gr. 3·75 to 4·0. (See Titanium.)

ANDALUSITE—A mineral trimorphous form of crystallized aluminium silicate (Al_2O_3,SiO_2), found in Andalusia (Spain) and elsewhere; of sp. gr. 3 to 3·3 and crystal system, No. 4; of some value as a refractory and for making porcelain cores of sparking plugs. (See Sillimanite.)

ANEMOMETERS—Instruments for measuring the direction, velocity, and force of the wind. Fletcher's anemometer is one designed to measure the speed of flue gases. (See *Chemical Engineering,* by G. E. Davis, i., 193, Davis Bros., Manchester.)

ANETHOL—See Aubepine and Aniseed Oil.

ANGELICA (*Archangelica officinalis*)—A plant, parts of which are used for flavouring purposes and in the rectification and compounding of gin. The root contains angelic acid ($C_5H_8O_2$), a crystalline, colourless substance, m.p. 45° C.; used in medicine as a stimulant.

The German and Japanese root oils, as also that distilled from the seeds (the yield being 1·15 per cent. and sp. gr. 0·86 to 0·89), are all used in medicine and the preparation of liqueurs. The distilled oil contains phellandrene and valeric acid.

ANGLESITE—Native lead sulphate (crystal system, No. 4, and sp. gr. about 6), found in Spain, North America, and Cumberland, probably produced by the oxidation of galena (lead sulphide).

ANGOSTURA—A bitter principle in the nature of an organic base, obtained from the bark of *Angostura* (*Cusparia febrifuga,* or *trifoliata*), originally made by the Capuchin Friars Mission on the River Carona in South America. The bark is stated to contain several alkaloids, including cusparine ($C_{19}H_{17}NO_3$), and another named galipine. It yields an oil of sp. gr. 0·93 to 0·96 soluble in alcohol and containing cadinene, etc. (See Späth and Papaioanow (*B.C.A.,* 1929, A, 1087) and Späth and Pikl (*B.C.A.,* 1929, A, 1319, and 1930, A, 1049).)

ÅNGSTRÖM UNITS—See Radio-activity (p. 750) and Wave-Lengths.

ANHYDRIDES—Substances resulting from the abstraction of the elements of water from other substances. For instance, the metallic hydroxides (of which potassium hydroxide (KHO) is illustrative) give the corresponding oxides or anhydrides by deprivation of water; thus, $2KHO = K_2O + H_2O$. Again, acetic anhydride ($C_4H_6O_3$) is similarly obtained from acetic acid; thus, $2C_2H_4O_2 = C_4H_6O_3 + H_2O$.

In a sense also cymene ($C_{10}H_{14}$) may be regarded as the anhydride of camphor, as by distillation with phosphoric anhydride it yields cymene, $C_{10}H_{16}O = C_{10}H_{14} + H_2O$.

ANHYDROUS—Devoid of water as a constituent.

ANILIDES—Compounds such as acetanilide, formed from aromatic amines by substitution of acyl groups for hydrogen in the amino group.

Magnesium anilide, $(NHPh)_2Mg$, is obtained as a light yellow powder when magnesium is heated at 370° to 380° C. with aniline vapour in the absence of air (*J.C.S. Abs.,* cxxvi., 1298).

ANILINE (**Amino-Benzene** or **Phenylamine**) (C_6H_5,NH_2) is an arylamine, being a derivative of ammonia, one hydrogen atom being replaced by the phenyl group, and is manufactured by acting on nitro-benzene with iron filings and hydrochloric acid or ferrous chloride, and subsequently

ANILINE (*Continued*)—

distilling with steam after the addition of lime. The following equation expresses the chemical change that thus takes place:

$$C_6H_5NO_2 + 3Fe + 6HCl = C_6H_5,NH_2 + 2H_2O + 3FeCl_2.$$

It can also be prepared from nitro-benzene by reduction, using sodium disulphide:

$$(C_6H_5NO_2 + Na_2S_2 + H_2O = C_6H_5NH_2 + Na_2S_2O_3).$$

In a later modification the reduction of nitro-benzene is effected by passing its vapour, mixed with hydrogen gas, over a catalyst at an appropriate temperature, while there is a modern process for its preparation from chlorobenzene. (See *C.T.J.*, 1929, **82**, 610; and Chlorobenzenes.)

Aniline oil gives off a poisonous vapour, and is the base or starting-point from which a great number of other "intermediates" for dyes are prepared, including dimethylaniline and diethylaniline, and these yield in turn many so-called basic dyes, such as methyl violet, methylene blue, and malachite green.

The physical constants of pure aniline, as recently determined, are as follows: fr.p., 6·24° C.; b.p., 184·32° to 184·39° C.; sp. gr., 1·0268; and ref. ind. at 20° C., 1·5850.

Aniline is an oily, colourless liquid of peculiar odour, which darkens on exposure to air, and finally dries up into a resin-like mass. It is soluble 1 in 31 parts water, also in alcohol and ether, and behaves as a base like ammonia, but is weaker, poisonous, and forms a number of combinations, including aniline hydrochloride (C_6H_5,NH_2,HCl). By boiling aniline with glacial acetic acid, a substance named "acetanilide" ($C_6H_5.NH.CO,CH_3$) is produced. otherwise known under the medicinal name of "antifebrine." (See Acetanilide.)

There are several homologues of aniline.

Aniline blue (phenyl-rosaniline) is prepared from aniline, magenta base, and benzoic acid.

(See work on aniline and its derivatives, by P. H. Groggins, Chapman and Hall, Ltd., London.)

ANILINE BLACK—A dye for cotton and other textiles produced by oxidation of aniline on the fabrics. (See reference to this substance by J. L. Hankey, *Chem. and Ind.*, 1930, **89**, 1027; and Dyes.)

ANILINE SALT—Aniline hydrochloride ($C_6H_5NH_2,HCl$), which crystallizes in large colourless plates, and can be distilled without change; m.p. 198° C., b.p. 198° C.; soluble in water, alcohol, and ether, and used in the dyeing industry.

ANIMAL CHARCOAL—See Bone Charcoal and Carbon.

ANIMAL CHEMISTRY—See Biochemistry.

ANIMAL MATTER—See Carbon.

ANIME RESIN (or **Gum**)—See Gums and Resins.

ANIONS—See Electricity and Ionization.

ANISALDEHYDE—See Perfumery.

ANISEED OIL (**Anise Oil**) is a yellowish, syrupy liquid of sp. gr. 0·975 to 0·990 at 15° C., and ref. ind. 1·55 to 1·56 at 25° C., of peculiar aromatic smell and taste. It solidifies at or below 15° C., and contains about 85 to 90 per cent. of anethol ($C_6H_4.C_3H_5(OCH_3)$ or $C_{10}H_{12}O$). Two dimerides of anethole are known. (See Goodall and Haworth, *J.C.S.*, 1930, 2482.) The oil is made from the seed of *Pimpinella anisum* (N.O. Umbelliferæ, cultivated in Spain, Malta, and Germany) by distillation with water, the yield of oil from the seeds being about 2·4 per cent. Another colourless variety, containing anethol, of sp. gr. 0·980 to 0·990, is made from the South China or star anise (*Illicium anisatum*) (5 per cent.) and the Japanese *Illicium religiosum* (1 per cent.). Reactions to distinguish these two oils are described in abstract form (*Analyst*, li., 254, and lii., 300). Aniseed oils are soluble in alcohol and ether, and are used in making liqueurs, for flavouring and as carminatives. Anethol is also obtained from fennel (*Anethum fœniculum*) and tarragon (*Artemisia dracunculus*). It is soluble in alcohol and ether, melts at 21° C. and boils at 235° C. (See Aubepine.)

ANKERITES (**Mineral Parts of Coal**)—See Coal.

ANNATTO—A fugitive colouring matter made from the seeds of the *Bixa orellano,* cultivated in Guiana, St. Domingo, and the Indies. It dissolves in alcohol to an orange-red colour, and is said to contain a crystalline yellow substance named bixin, which in the presence of alkalies absorbs oxygen and turns red. It is used in dyeing and wood-staining, also for colouring butter, cheese, etc.

ANODE—See Electricity.

ANORTHITE ($[Al_2O_2(SiO_3)]Ca$)—A mineral compound silicate of aluminium and calcium of sp. gr. 2·7 and crystal system, No. 6.

ANTHOCYANS—See Plant Colouring Matters.

ANTHOXANTHENES (**Anthoxanthins**)—See Robinson (with others), *J.C.S.,* 1929, pp. 61-84, and Plant Colouring Matters.

ANTHRACENE ($C_{14}H_{10}$ or $C_6H_4.CH.CH.C_6H_4$)—A product of the destructive distillation of coal, present in coal-tar to the extent of from ¼ to nearly ½ per cent. In the pure state it is a yellow crystalline body, and exhibits a fine blue fluorescence. It is obtained from the anthracene oil, which forms about 12 to 17 per cent. of the tar and distils over between 270° and 300° C. Upon cooling, the crystals of anthracene are separated from the oily mother-liquor by pressing and centrifugalizing. This crude product, containing about 40 to 45 per cent. anthracene, is further purified from naphthalene, phenanthrene, crysene, carbazole, and other associated bodies, by exposure to steam in a hydraulic press, after which it is washed with a mixture of solvent naphtha mixed with pyridine bases. In this way a product containing about 90 per cent. anthracene can be obtained. By dissolving the crude article in furfural at an elevated temperature and subsequent cooling, anthracene of excellent quality for direct oxidation to anthraquinone separates out.

ANTHRACENE (*Continued*)—

Chemically pure anthracene is obtained by grinding up the crude substance with caustic potash and lime, and redistillation, the product being finally washed with solvent and sublimed. The Jaeger solvent process for its purification is the subject of British Patent No. 304,179, dated January 6, 1928, and a description of "New Catalytic Processes" for anthracene purification, by A. O. Jaeger, is given in *C.T.J.*, 1930, **86**, 141. Anthracene, m.p. 218° C., b.p. 340° C., is used for making anthraquinone and various aniline colours, especially Turkey red. (See Orlov and Lichatschiev on the "Berginization of Anthracene" (*B.C.A.*, 1930, A, 1425; *Anthracene and Anthraquinone*, by J. Houben, Verlag von Georg Thieme, Leipzig; and Alizarin.)

ANTHRACITE—See Coal.

"ANTHRACOAL"—A substitute for coal made by coking a mixture of culm or waste anthracite coal and coal-tar pitch or bitumen.

ANTHRANILIC ACID (*o*-**Amino-benzoic Acid** ($C_6H_4.NH_2.CO_2H$))—A yellow crystalline salt, m.p. 144° C., soluble in water, alcohol, and ether; used in the dye industry. (See Indigo.)

ANTHRAQUINONE ($C_{14}H_8O_2$ or $C_6H_4(CO)_2C_6H_4$)—A product of the oxidation of anthracene; also manufactured by the catalytic oxidation of naphthalene to phthalic anhydride by Gibb's vapour-phase process and the condensation of the products with benzene in presence of aluminium chloride. It crystallizes in yellow needles, m.p., 285° C., is readily sublimable, soluble in alcohol, ether, and acetone, and used in the dyestuffs industry. (See *C.T.J.*, 1922, **71**, 399; C. H. Rasch, *B.C.A.*, 1929, B, 886; Mitter and Sarkar, *B.C.A.*, 1930, A, 1439; and Anthracene.)

ANTI-BODIES—Substances produced in the blood which counteract injected foreign bodies such as proteins. (See Bacteria and Toxins.)

ANTICHLOR—A term used by bleachers in respect of chemicals (such as sodium sulphite and sodium thiosulphate), employed for the purpose of obviating any deleterious after-effects of the action of chlorine preparations used in bleaching operations by removing any excess chlorine.

ANTIFEBRINE—See Acetanilide.

ANTI-FOULING COMPOSITIONS—See Paints.

ANTI-GENS—Bodies which when injected into the blood produce anti-bodies. (See Bacteria and Toxins.)

ANTI-KNOCK FUELS—See Motor Spirit, Selenium and Tellurium (p. 904).

ANTIMONY (Stibium, Sb) **and its Compounds**—Atomic weight 121·76, credited with two isotopes; sp. gr. 5·73; m.p. 630° C., and crystalline system, No. 3. A number of recorded determinations show the atomic weight as 121·744 to 121·754. Antimony is found naturally in small quantities, but in greater quantities it exists combined with oxygen as

ANTIMONY (*Continued*)—

so-called *white antimony* (Sb_2O_3), and in another form as *antimony ochre* (Sb_2O_4) (sp. gr. about 3·75). Its chief ores are *stibnite* (Sb_2S_3) or *grey antimony ore, antimony blende* ($Sb_2O_3 2Sb_2S_3$) (crystal system 4, and sp. gr. about 4·5), and *red antimony* or *kermisite* ($(2Sb_2S_3) Sb_2O_3$). Antimony mining is conducted in Asia Minor, Bolivia, Borneo, China, France, Hungary, Mexico, New South Wales, the United States of America, and elsewhere.

Antimony is a bright bluish-white metal largely used in making *type metal, stereotype metal,* and *Britannia metal* (all of which give fine and sharp castings), and as an ingredient of some anti-friction or bearing alloys, the average annual consumption being about 21,500 tons.

The precipitated form known as antimony black is used for producing the appearance of polished steel on *papier mâché* and pottery, etc.; colloidal antimony in several combinations is used in therapy; the tetroxide is used for rendering enamels opaque, and the trioxide for colouring glass, and as a paint. The red sulphide is used for vulcanizing rubber and for preparing the striking surface on safety-match boxes.

Alloyed with lead, it was largely used in the Great War in preparing shrapnel bullets, and the sulphide in making shell primers and as a smoke producer.

The metal is prepared by heating the broken-up native trisulphide with half its weight of scrap iron in plumbago and fire-clay crucibles or a reverberatory furnace, when iron sulphide is formed, and the metallic antimony set free, as follows:

$$Sb_2S_3 + 3Fe = 2Sb + 3FeS;$$

or the selected sulphide after separation from the associated rocky matter of the ore can be roasted in a reverberatory furnace; the sulphur in this way is burnt off as sulphur dioxide, and the resulting oxide is then reduced by strongly heating with carbon. The recovery of antimony from the waste-heap following upon the smelting of non-ferrous residues in the blast furnace is the subject of a note in the *C.T.J.*, 1926, **78**, 691.

When a concentrated solution of the trichloride in hydrochloric acid is subjected to electrolysis, using an anode of ordinary antimony and a cathode of platinum wire, a highly lustrous substance of metallic appearance is deposited on the cathode, and when this is scratched or knocked it becomes strongly heated, due to the increased transformation of a metastable or so-called explosive form of the metal into the more stable form—a change which has been explained by E. Cohen (*Chem. and Ind.*, 1929, **48**, 165) as an instance of monotropy. This explosive difficulty is stated to be overcome by the use of hydrofluoric acid instead of hydrochloric acid. The use of an alkaline electrolyte in place of an acid one presents some advantages: antimony sulphide is dissolved in a solution of sodium sulphide ($Sb_2S_3 + 3Na_2S = 2Na_3SbS_3$), and this can be readily electrolyzed.

Increased attention is being paid to various electrolytic methods on account of the high purity of the metal thus produced, and for other reasons. (See Isgarischev and Pletenev (*B.C.A.*, 1931, B, 846).)

ANTIMONY (*Continued*)—

Antimony boils at about 1,300° C. and volatilizes at about 1,500° C.; it is a bad conductor of heat and electricity, and is not acted upon by the air, but when strongly heated it burns in air or oxygen with a brilliant light and forms antimony trioxide (Sb_2O_3).

This oxide, prepared by roasting the sulphide ore in a blast furnace and collecting the vapour, is now used as the basis of a white pigment in substitution for white lead. (See "Timonox.")

When thrown into chlorine gas the metal takes fire and forms antimony trichloride ($SbCl_3$); this trichloride is also produced by dissolving antimony sulphide in strong hydrochloric acid and a trace of nitric acid, followed by evaporation to dryness. The trichloride is used in fire-proofing and medicine, and there is a pentachloride ($SbCl_5$).

The trioxide (Sb_2O_3), is volatile at relatively low temperatures and occurs in mineral form as *valentinite* and *senarmontite*. It can be prepared by oxidation of the metal and is used as a pigment. The tetroxide (Sb_2O_4) is practically non-volatile, although it decomposes at 930° C. into the trioxide and oxygen: it is used in enamel making and known also in mineral form as *cervantite*. It is stated that the pentoxide (Sb_2O_5) cannot be prepared by direct oxidation, but can be made from potassium antimonate in a wet way.

The trichloride (butter of antimony) is a colourless, crystalline body, soluble in water and alcohol, and is used in bronzing iron, also as a mordant for making lakes and colouring zinc black.

When the trioxide is dissolved in a boiling solution of potassium hydrogen tartrate (*cream of tartar*), potassium-antimony tartrate or *tartar emetic* is formed. This compound is used medicinally, and in the leather and dyeing trades, a commercial form being marketed of 43 to 44 per cent.

Two sulphides are known, both of which are insoluble in water—viz., the trisulphide (Sb_2S_3), which is used variously as a red pigment, for lining lead chambers used in manufacturing sulphuric acid, and in match making; whilst the pentasulphide (Sb_2S_5) is used in the manufacture of red rubber, and is known also as "golden sulphide of antimony." This substance as obtained by precipitation would appear to be really a mixture of tetrasulphide (Sb_2S_4) and sulphur, its production from Schlippes' salt by action of dilute acid being probably represented as follows:

$$2Na_3SbS_4 + 6HCl = 6NaCl + 3H_2S + Sb_2S_4 + S.$$

The trisulphide occurs in nature as above stated, and when precipitated from solutions it is an orange-red compound.

Antimony hydride or antimoniuretted hydrogen (SbH_3) is produced when an antimonial solution is brought into contact with zinc and sulphuric acid. It is a colourless gas of offensive odour, which can be obtained also in liquid and solid forms.

A solid dihydride can also be prepared (see Weeks and Druce, *J.C.S.*, cxxvii., 1069 T).

ANTIMONY (*Continued*)—

Antimony lactate ($Sb(C_3H_5O_3)_3$); soluble in water, and used as a mordant.

Antimony phosphate ($5SbPO_4,2H_2O$) has been described by S. M. Horsch (*B.C.A.*, 1929, A, 779).

Fluorides (SbF_3 and SbF_5)—Soluble in water and used in ceramics.

Sulphate ($Sb_2(SO_4)_3$)—Prepared from the trioxide by action of sulphuric acid, is a white powder decomposed by water and used in pyrotechny.

Antimony forms compounds with the alkyls similar to those of arsenic—for example, trimethyl-stibine, $Sb(CH_3)_3$, a disagreeable inflammable liquid. (See Naples Yellow.)

The Antimony Products, Ltd., Works are described in the *Ind. Chem.*, iv., 229, and a detailed account of the uses of antimony compounds is given by "Omega" (*C.T.J.*, 1928, **83**, 337 and 363). (See also paper on "The Chemotherapy of Antimony," by Gray, Trevan, and Bainbridge (*Chem. and Ind.*, 1931, **50**, 215).)

ANTIMONY VERMILION—Trade name for antimony trisulphide or oxysulphide.

ANTI-OXIDANTS—Bodies which, when present in small amount, prevent the rapid oxidation of substances otherwise susceptible to that change. Some are used for prohibiting or delaying the rancidity of oils and fats, and articles made from them, such as pastry, the perishing of rubber and linoleum, the formation of gum in petrol, etc.

They include many antiseptics, some being of the phenol class and others, such as sodium sulphite, for preventing the oxidation of certain organic compounds. (See H. A. Mattill (*Analyst*, 1931, **56**, 200), Hilditch and Sleightholme (*J.S.C.I.*, 1932, **51**, 39 T), and Catalysis.)

ANTIPYRETICS—Substances used as febrifuges by reducing temperature and to alleviate pain, such as antipyrine, phenacetine, etc.

ANTIPYRINE (**Phenazone**) ($C_{11}H_{12}N_2O$ or $C_6H_5(CH_3)_2C_3HN_2O$)—A white crystalline substance, m.p. 113° C., soluble in water, alcohol, and ether, constituting an excellent febrifuge and alleviative to neuralgic pains. With respect to its synthesis, see Viliaschko and Blizniukov (*B.C.A.*, 1930, A, 1193).

ANTISEPTICS—Preventives of septic poisoning or putrefactive decomposition, some of which act by inhibition and others by destruction of the micro-organic forms which originate putrefaction and septic processes. Inhibition may be brought about by direct interference with the living functions of the micro-organisms or indirectly by rendering the medium unfit for their life and multiplication. The non-poisonous varieties, such as "Sanitas" fluid, are of service for dressing wounds and sores, as mouth washes and gargles (particularly in septic cases), and for the preservation of adhesive pastes, foods, etc. There are an immense number of chemical substances and proprietary preparations, many of which are useful according to their respective other proper-

ANTISEPTICS (*Continued*)—

ties and the applications to be made of them. Many so-called disinfectant preparations act specifically as antiseptics, and a number of them are described under their respective names.

Antiseptics and some methods of testing them form the subject of an article by T. H. Fairbrother and A. Renshaw (*Ind. Chem.*, i., 371 and 419); see also Bacteria, Disinfectants, Dyes, and Germicides.

ANTITOXINS—See Toxins.

APATITE—A mineral compound consisting chiefly of phosphate and fluoride of calcium ($3Ca_3(PO_4)_2CaF_2$), of crystal system, No. 3, and sp. gr. about 3·0; found chiefly in Canada and Norway, although deposits occur in Brazil, the U.S.A., and elsewhere. (Compare S. N. Szabó as to its structure (*B.C.A.*, 1931, A, 550); see also G. Carobbi (*B.C.A.*, 1931, A, 1029).)

APIOL—A pale green oil of m.p. 30° C. obtained from the fruit of parsley (*Petroselinum sativum*), used as a diuretic. (See J. King on "The Identification of Apiol," *Analyst*, 1929, **54**, 567, and Parsley Oils.)

"AQUADAG"—See Lubricants.

AQUA FORTIS—An old name for nitric acid.

AQUA REGIA—A mixture of nitric and hydrochloric acids—a very powerful solvent. Gold and platinum, for example, can be dissolved by this mixture, which is commonly made of 18 parts and 82 parts of the respective acids.

AQUEOUS VAPOUR (Atmospheric)—The water or moisture held dissolved in vaporous solution in the air. (See Air and Hygroscopic.)

ARABIC GUM—See Gums and Resins.

ARABINOSE ($C_5H_{10}O_5$)—A white crystalline sugar body soluble in water, m.p. 159° C.; it is a constituent of many plants, and can be made by boiling beetroot chips, gum arabic, or cherry gum with dilute sulphuric acid. (See Carbohydrates, Glucosides, and Xylose.)

ARACHIDIC (ARACHIC) ACID ($C_{20}H_{40}O_2$)—A member of the normal fatty acids, found in the oil of the earth-nut (*Arachis hypogæa*). It is a crystalline body, m.p. 75° C., soluble in boiling alcohol and in ether. (See Arachis Oil.)

ARACHIS OIL (Earth-Nut Oil, Ground-Nut Oil, Nut Oil, Pea-Nut Oil)—A fatty oil, of which there are many grades, expressed from the fruit (pea-nuts) of *Arachis hypogæa*, a leguminous plant indigenous in India, South Africa, and South America, and cultivated in China, Senegal, and Japan. The area under cultivation in India has recently been reported as 5,643,000 acres, yielding some 2,475,000 tons of nuts in shell. The oil is pale yellow, of agreeable odour and non-drying character; soluble in alcohol, ether, benzol, and carbon disulphide; has a sp. gr. of 0·916 to 0·925, ref. ind. 1·4612 at 40° C., sap. v. 185 to 196, and i.v. 85·2. It is used variously as a salad oil and substitute for

ARACHIS OIL (*Continued*)—

olive oil, also for soap-making, in the textile trade, in chocolate making, for oiling wood, and as a delicate lubricant for watchmakers' use, etc. Chemically, it is a mixture of glycerides.

One account of the fatty acids obtained from a sample with an iodine value of 86·1 showed the presence of 2·3 arachidic acid, 1·9 lignoceric acid, 4·5 stearic acid, 4·0 palmitic acid, 79·9 oleic acid, and 7·4 per cent. linoleic acid.

Other published analyses are as follows:

	From Virginia Nuts.	From Spanish Nuts.
	Per Cent.	Per Cent.
Lignoceric acid ..	2·6	3·1
Arachidic acid ..	3·3	4·0
Stearic acid	4·9	6·2
Palmitic acid ..	6·3	8·2
Linoleic acid ..	21·6	24·7
Oleic acid	60·6	52·9
Iodine value	94·8	90·1

A later determination gives 21·2 per cent. glycerides of saturated acids, 55·66 per cent. olein, and 23·14 per cent. linolein as the composition of this oil.

The decorticated nuts yield about 48 per cent. and the undecorticated nuts about 37 per cent. of oil.

The trade in pea-nuts is the chief trade of Senegal. Ground-nut cake contains from 5½ to 16 per cent. oil, 25 to 57 per cent. albuminoids, and 14 to 29 per cent. digestible carbohydrates, according to variety and method of preparation, and is a good feeding stock. Pea-nut flour is stated to have a good protein value, and can be admixed to advantage with wheat flour for biscuit making, etc.; it is also alleged that alcohol can be manufactured cheaply from pea-nut hulls. More recent analytical details concerning the fatty acid contents of this oil are given by D. Holde (with others) (*B.C.A.*, 1929, B, 785) and by T. P. Hilditch and N. L. Vidyarthi, *J.S.C.I.*, 1927, **46,** 172 T.) With respect to the proteins contained in the arachis nut, see Jones and Horn (*Analyst,* 1930, **55,** 395.) The nut-shells can, it is stated, by suitable chemical treatment be made available for use in paper and silk-substitutes manufacturing. (See Cruz and West on the "Philippine Oil" (*B.C.A.*, 1931, B, 1105) and Lynch and Goss on "Pea-nut Hull Cellulose" (*B.C.A.*, 1930, B, 984).)

ARAGONITE ($CaCO_3$)—Of crystal system, No. 4. (See Calcium.)

ARARA NUT OIL from the *Joannesia heveoides* Ducke (N.O. Euphorbiaceæ) of Brazil is described as having sp. gr. about 0·924; ref. ind. n.D. 20° C., 1·468; acid. v. 0·4 to 2·1; sap. v., 188·5 to 191·6; i.v. (Hubl), about 130; and unsaponifiable content about 0·5 per cent. and

ARARA NUT OIL (*Continued*)—useful for soap-making. Both oil and meal have toxic properties. (See *Analyst*, 1929, **54**, 177.)

ARCHIL (**Orchil**)—A purple dye obtained from many kinds of lichens, including the geni *Rocella, Variolaria orcina, Lecanora,* etc., a number of which contain certain colourless acids of the type of lecanoric acid which are capable of transformation into a colourless substance termed *orcin*, which, by the action of air and ammonia, is changed into the purple body called *orcein* ($C_{28}H_{24}N_2O_7$)—the colouring principle of archil. Lecanoric acid is stated to be first of all changed into orsellinic acid. The *Rocella peruviana* occurs in abundance around Magdalena Bay (Lower California), as much as 100,000 tons being harvested in 1917. The lichen is torn from the trees, and, after drying, is ground to a coarse powder, and then macerated during several weeks in dilute ammonia with frequent stirring.

According to other accounts, the lichens are treated with a solution of potash or milk of lime, and from the extracts the "colouring acids" are precipitated by means of hydrochloric or acetic acid. One of the dyes commercially obtained from these lichens is known as "French purple."

Orsellinic acid yields orcinol, $C_6H_3(CH_3)(OH)_2$, upon fusion of aloes extract with potash by the elimination of carbon dioxide as follows:

$$C_6H_2(CH_3)(OH)_2COOH = C_6H_3(CH_3).(OH)_2 + CO_2,$$

and the orcinol thus produced crystallizes from its aqueous solution with water of crystallization. (See Orcinol.)

Archil comes to the market in three forms, known respectively as "archil" (paste), "persis" (dry paste), and "cudbear" (a reddish powder). It is expensive and perishable, and is used as a dye for cloth, wools, and silk.

ARECA (**Betel**)—A genus of plants cultivated in tropical India, the Philippines, and East Indian Islands, including the *Areca catechu*, the ground-nut of which contains numerous alkaloids and is used as a vermifuge, especially for dogs.

ARGEMONE OIL (**Mexican Poppy Oil**)—A brownish-yellow oil obtained up to about 36·5 per cent. by extraction from the seeds of the Mexican prickly pear (*Argemone mexicana*, of the natural order Papaveraceæ), unsuitable for paint or edible use, but similar to cotton-seed oil and constituting a useful soap-making material. It is also used as a lubricant and illuminant in Mexico and the West Indies, and the meal left after extraction is a good fertilizer. Its sp. gr. is 0·9220 at 15° / 15° C., sap. v. 192·7, i.v. 123·7, acid. v. 12, acet. v. 39, and it contains palmitic stearic, oleic, linoleic, linolenic, and ricinoleic acids, etc.

ARGENTITE (**"Silver Glance"**)—A native form of silver sulphide (Ag_2S) occurring in cubic crystals (crystal system, No. 1, and sp. gr. about 7·2), containing 87 per cent. silver, found in several of the United States of America.

ARGENTOJAROSITE—A silver mineral found at Dividend, Utah, having the approximate composition represented by the formula:

$$Ag_2O.3Fe_2O_3.4SO_2.6H_2O.$$

ARGHAN—A fibre cultivated in the Federated Malay States, said to be superior in tensile strength to all other fibres of its class; of remarkable salt-water resisting quality, and of value in the manufacture of twine, cordages, fishing-net yarns, tapes, and beltings; also possibly qualified to take the place of cotton for all classes of heavy canvas as woven in Lancashire.

ARGILLACEOUS—Clay-like in character.

ARGININE—An amino-acid derived from certain proteins by hydrolysis and regarded as a valuable food factor. (See Kiech, Luck, and Smith (*J. Biol. Chem.*, 1931, **90,** 677).)

ARGOL—Crude tartar as deposited in wine casks or at the bottoms of fermenting vessels. These crystals contain from 60 to 75 per cent. of potassium bitartrate; the higher the alcoholic content of the wine the lower is the amount precipitated, so that ordinary red wines with 9° of alcohol give more than higher grades with 12° to 20° alcohol. The product is used in the dyeing, silver smelting, and baking-powder industries. (See Tartar and *C.T.J.*, 1928, **83,** 338.)

ARGON (A)—Atomic weight 39·94, credited with two isotopes. Argon is an element found present in the gaseous state in the air to the extent of rather less than 1 per cent. by volume, and also in minute quantity in Bath and other mineral spring waters. It is isolated by processes which remove the oxygen and nitrogen respectively, as, for example, passing a current of air over calcium carbide at 800° C. ($2CaC_2 + O_2 = 2CaO + 4C$ and $CaC_2 + N_2 = CaN_2 + C$). It is a remarkably inert substance, and has been liquefied and frozen to a white solid. It has found application to the extent of a hundred million litres for gas-filled electric lamps annually, the filaments proving less destructible than *in vacuo*. No chemical combinations of it are known. The density of the gas is 19·94; it is soluble in water to the extent of 4·1 volumes in 100 at 15°C. and boils at 187° below 0° C. According to Ramsay, the fractional distillation of argon yields traces of other gases having distinct spectra, and to these he gave the names of Neon, Xenon, and Krypton. (See Air.)

"ARMCO"—An extremely pure form of iron (99·84 per cent.). Strain-hardened "Armco" can be further hardened by temperatures between 150° and 390° C., and both its strain-hardening and temperature-hardening qualities occur during a creep test, while its plasticity is said to decrease and give place to perfect elasticity under conditions of prolonged stress at temperatures below the limiting creep values.

ARNICA—The dried flower-heads of *Arnica montana* (Central Europe); used in medicine, as is also the oil obtained from them by distillation. The oil is yellow in colour, has a sp. gr. 0·906, sap. v. 30, and is soluble in alcohol.

AROMATIC ALCOHOLS—Respecting their synthetic production and properties, see J. McLang, *C.T.J.*, 1926, **79,** 496.

AROMATIC ALDEHYDES—These are used to a considerable extent in the perfume industry. (See Benzaldehyde and Perfumes.)

AROMATIC COMPOUNDS—Those derived from benzene with rings or closed chains of carbon atoms as distinct from those of aliphatic character. (See Chains.)

ARRACK—A spirituous drink containing from 20 to 26 per cent. alcohol, prepared by the fermentation of an infusion of rice. A similar preparation known as "palm wine" is made in Ceylon from coco-nut toddy.

ARRAGONITE—Calcium carbonate of crystal system, No. 4, and sp. gr. about 3. (See Calcium.)

ARROWROOT—See Adhesives and Starch.

ARSENIC (As) **and its Compounds**—Atomic weight, 74·937 and isotope 75; sp. gr. (crystalline variety, system No. 3), 5·73; vapour density, 150; m.p. 850° C. (under pressure). Arsenic occurs in nature in Cornwall and elsewhere in the metallic state and in combination with sulphur as *realgar* (As_2S_2) (crystal system, No. 5, and sp. gr. 3·5) and *orpiment* (As_2S_3). It is also found in other combinations—viz., with iron (*arsenopyrite* or *arsenical iron,* $FeAs_2$ and Fe_4As_3); *mispickel* ($FeS_2 + FeAs_2$); with nickel (*kupfernickel,* NiAs and $NiAs_2$), and with cobalt. *Arsenopyrite* occurs abundantly in Ontario, and there are *orpiment* mines in Chitral, while some arsenic is produced in Queensland, Western Australia, Vancouver, U.S.A., France, Sweden, and Cornwall, but it is chiefly produced from the silver-cobalt-nickel-arsenic ores of the Ontario cobalt district as a by-product.

It is of grey colour, sublimes at 450° C. without melting, and is used for mixing in small proportion with melted lead to make shots, which are harder than those made with pure lead.

The metal is recoverable from the flues of pyrites burners, and can be manufactured from arsenical pyrites by roasting it in vessels fitted with suitable condensers for receiving the arsenic which is liberated and volatilized by the splitting up that occurs, ferrous sulphide being left behind—

$$FeS_2,FeAs_2 = 2FeS + 2As.$$

In two forms it is crystalline (yellow and metallic), and is a good conductor of heat and electricity, but an amorphous form is also known.

Arsenic Hydride (AsH_3), otherwise known as "arsine" and "arseniuretted hydrogen," is an offensive smelling, colourless, poisonous gas which can be prepared by the action of dilute hydrochloric or sulphuric acid upon an alloy of arsenic and zinc. It is alleged that 3 parts per 100,000 parts of air will cause symptoms of poisoning in time. It burns with a bluish flame, forming water and arsenious oxide, but if the amount of air is limited, metallic arsenic is deposited. The so-called Marsh's test is based on this change. An improved form of the electrolytic Marsh type apparatus is described by Julius Grant (*Analyst,* 1928, **53,** 626); see also Colley and Lockwood on the Marsh-Berzelius method

ARSENIC (*Continued*)—

(*J.S.C.I.*, 1929, **48**, 226 T), and A. J. Linsey on "A Modified Gutzeit Arsenic Apparatus" (*Analyst*, 1930, **55**, 503).

Other hydrides are described as As_2H_2 and a solid one AS_4H_2.

Arsenious Oxide (As_2O_3), known also as "white arsenic," occurs naturally as the rare mineral *arsenite*, and is manufactured as a secondary product in the roasting of many arsenical ores for the recovery of the associated metals—nickel, cobalt, silver, and tin—large quantities being recovered from the smelter fume in the U.S.A. [chiefly at Bute (Mass.), Tintic (Utah), and Tacona (Wash.)]. It is used not only in the manufacture of rat poison, certain pigments, and flint glass, but largely for the preparation of sodium arsenite (Na_2HAsO_3), which is made by dissolving the oxide in caustic soda or sodium carbonate solution, and used as a weed-killer and horticultural insecticide. The arsenates, however, are said to be less toxic and less destructive to foliage than the arsenites, and although dearer are therefore to be preferred as insecticides. (See Calcium Arsenate, Sodium Arsenates, and Insecticides.) Arsenious oxide is soluble in water and alcohol and is very poisonous, as are also most of the arsenical compounds. The U.S.A. production in 1930 is given as 17,057 short tons, while the world's production of white arsenic has been estimated at about 25,000 tons per annum.

Ortho-Arsenic Acid (H_3AsO_4), prepared by action of nitric acid on metallic arsenic or arsenious oxide, is a white crystalline salt soluble in water, and used as an insecticide.

Arsenic Pentoxide (As_2O_5), a white deliquescent substance soluble in water, is obtained by oxidizing arsenious oxide with nitric acid.

Arsenic Disulphide (As_2S_2) is an orange-red powder insoluble in water, prepared by roasting *mispickel* or other ores containing both arsenic and sulphur, and sublimation. It is used in a number of industries, including calico printing, the manufacture of leather, shots, and paints, and as a depilatory agent. Its native form (*realgar*), by the action of light, disintegrates to a reddish-yellow mixture of As_2S_3 and As_2O_3 with some As_4S_3.

The trisulphide (As_2S_3) (found native as *orpiment*) and the pentasulphide (As_2S_5) are yellow substances insoluble in water, used as pigments in paint-making.

Arsenic resembles phosphorus and nitrogen in the sense that it forms analogous compounds with alkyl radicals, as, for example, tri-methyl arsine, which is analogous to tri-methylamine and tri-methyl phosphine. (See "The Mechanism of the Action of Arsenicals," by H. King (*Chem. and Ind.*, 1930, **49**, 786); and H. J. Barber (*Ibid.*, **49**, 802); Cacodyl; also Reinsch's Test.)

"ARSENIC ORANGE"—Arsenic disulphide.

ARSENOBENZENE ($C_6H_5.As:As.C_6H_5$) is a yellow crystalline body of m.p. 196° C., derivatives of which have proved of value in the treatment of certain diseases. (See Salvarsan.)

"ARSENOBENZOL"—The British equivalent of salvarsan, used as a remedy for certain toxic effects.

ARSINE—See Arsenic (Hydride).

ARTIFICIAL SILK—See Silk Substitutes, "Rayon," Celanese, and Cellulose.

ARTIST'S COLOURS—See Paints.

ARUM—See Starch.

ARYLS—A group of radicals, including, *e.g.*, phenyl, originating from aromatic compounds, as distinct from the alkyls; aniline is typical of the so-called *arylamines*. (See Amines.)

ASAFŒTIDA—See Gums and Resins.

ASARUM OIL is marketed in two varieties, both of which are used in perfumery. They are distilled from the rhizome and roots of the respective plants, the *Canadense* oil having a sp.gr. of 0·930 to 0·960, and the *Europæum* variety having a sp. gr. of 1·015 to 1·068. These pungent oils contain pinene, linalol, borneol, guaiacol, etc., are soluble in alcohol, ether, etc., and used in perfumery.

ASBESTINE (Agalite)—A mineral occurring in the eastern States of America and South Germany, intermediate in chemical and physical characters between talc and asbestos, of average composition: silica 49·81 per cent., alumina 2·19 per cent., iron-oxide 2·8 per cent., magnesia 27·96 per cent., lime 13·21 per cent., and water 3·91 per cent. Freed from its iron content, it is employed as a filler and in the rubber and paint industries.

ASBESTOS—A fibrous variety of the mineral *amphibole,* being a compound silicate and aluminate of magnesium, calcium, and iron. The name, however, is applied not only to the minerals *uralite, tremolite, actinolite,* and other varieties of amphibole, but to fibrous forms of *pyroxene,* the different mineral *crocidolite* of the *amphibole* group (distinguished by its large proportion of ferrous iron constituent), and to *chrysotile,* a white fibrous variety of serpentine which differs in that it is the most highly hydrated silicate, whereas some of the others are anhydrous. The three principal varieties are *anthophyllite, amphibole,* and the *serpentine.*

Large commercial (*chrysotile*) supplies of the serpentine group come from the Province of Quebec and Rhodesia, but asbestos occurs also in Cyprus, China, Italy, and many of the U.S.A., while *chrysotile* deposits are found in Russia. The South African supplies include *chrysotile, crocidolite* (blue asbestos), and *amosite.* The Canadian production of asbestos in 1928 amounted to 273,865 tons.

Blue asbestos (*hornblende* or *amosite*), found chiefly in South Africa, is reported as superior to the white varieties as a non-conductor, in tensile strength, and resistance to acids, and loses only 5 per cent. on ignition as against 15 per cent. suffered by white asbestos. It is peculiarly suitable for fuming-sulphuric acid plants and as a covering for steam boilers and pipes. Its fibres are longer than those of the ordinary white variety, and it will save 93 to 94 per cent. of the loss from a bare steampipe at over 300 lbs. pressure and lasts indefinitely.

The long-fibred asbestos is manufactured into cloth and fabrics for fireproof clothing, theatre curtains, yarn, packing, boiler coverings,

ASBESTOS (*Continued*)—

and many other useful commodities, while the shorter fibres are employed for making joints and in compounding a number of building and roofing materials, cements, and paints. It withstands heating to a high temperature, and, as it is not acted upon by many chemicals, is often employed in laboratories; for example, in the form of fibres for plugging the ends of glass tubes in order to retain their chemical contents within prescribed limits; also as a covering or in the form of woven mats or cloths for the central part of wire gauze used on the top of iron tripod stands, thus preventing oxidation by rusting, and affording a softer seat for glass vessels placed thereon when required to be heated by lamps below, and for the better distribution of the flame. In the fibrous form it is also employed as a filtering material wherewith to plug the neck of funnels for separating solid and liquid materials, particularly when it is known that a paper filter would become easily clogged or destroyed by the particular chemical agent in use; and although the filtrate may not be quite clear, it may then admit of more rapid and perfect filtration through an ordinary paper filter.

The following table of average composition of the principal types is taken from a detailed memorandum prepared by the Natural Resources Intelligence Service, Canadian Department of the Interior, Ottawa. (See *C.T.J.*, 1926, **78,** 625, and 1927, **81,** 107; J. N. Longley (*Chem. and Ind.*, 1927, **46,** 525); C. Jourdan (*B.C.A.*, 1927, A, 955); and letter by A. J. Dunk (*Chem. and Ind.*, 1927, **46,** 601).)

	Chrysotile. $3MgO,2SiO_2,2H_2O$.	Crocidolite. $NaFe(SiO_3)_2,FeSiO_3,H_2O$(Type).
SiO_2	40·49	51·22
Al_2O_3	1·27	—
Fe_2O_3 and FeO ..	2·58	34·02
MgO	41·41	2·48
CaO	—	0·03
Na_2O	—	7·07
H_2O	14·06	4·50
MnO_2	—	0·10

Blue crocidolite of South Africa is given the formula $3H_2O,2Na_2O,6(Fe,Mg)O,2Fe_2O_3,17SiO_2$ and described as an orthorhombic amphibole with ferrous oxide as the dominant base, by M. A. Peacock (*B.C.A.*, 1929, A, 787). (See Amphibole, Chrysotile, Hornblende and Uralite.)

ASCARIDOLE—See Wormseed Oil.

"ASCARITE"—A mixture of sodium hydroxide and asbestos, used as a carbon dioxide absorbent.

"ASEPTOL"—A trade name for an antiseptic solution of phenol-sulphonic acid ($C_6H_4(OH)SO_3H$).

"ASEPTOSOL"—An antiseptic phenol, being one of the constituents of *chavicol,* both of which are prepared from an ethereal oil derived from the leaves of *Chavica Betle,* indigenous to the East Indies, which have long been chewed by the natives to whiten and preserve the teeth. It is more active than *chavicol,* has a m.p. 15·8° C., b.p. 230° to 231° C., and sp. gr. at 15° C. of 1·0203; pure white, with an odour reminiscent of phenol (J. McLang, *C.T.J.*, 1926, **78,** 560).

ASHES—All vegetable growths, as well as coal, peat, and lignite, leave ashes when burned, and all of them contain some amount of alkali. Potash was originally produced from the ashes of plants, and there is a process for its recovery from the coal used in blast furnaces. (See Potassium.) Estimated as K_2O it amounts to from about 10 per cent. in the ashes of straw to 42 per cent. in that from peas. The potash is associated with varying amounts of soda, lime, magnesia, iron oxide, sulphur (in the form of sulphates), silica, carbon dioxide, and phosphoric acid. The woods which yield the greatest amount of potash are wormwood and fumitory.

The recovery of fuel from ashes can be at times economically effected by various methods, the oldest one being by wet extraction or a process of washing, which, however, does not appear to be suitable when the ashes contain a large proportion of fine breeze. It depends upon the difference in the specific gravities of the coke and the clinker, but, of course, the recovered fuel is saturated with water, and until air-dried may contain up to 25 per cent. of water.

A more modern treatment in respect of coal is effected by what is known as the Dry Magnetic Process (Ulrich's), which depends upon the presence of iron in the form of pyrites in practically all coals, the separation of the fuel from the clinker being carried out on the periphery of a rotating drum in which two electro-magnets are fixed, the slag being attracted by the field as the ashes pass over the drums, and the non-magnetic coke being automatically projected over a partition and discharged into trucks.

The ash from powdered fuel installations is the subject of an article by J. T. Dunn. (See *J.S.C.I.*, 1926, **45,** 60 T.)

ASPARAGINE ($C_4H_8N_2O_3$ or $CO_2H.CH(NH_2).CH_2.CONH_2$)—An acid amide body contained in asparagus, potatoes, beetroots, vetches, and the juices of other vegetables including the marsh mallow, liquorice juice, the tubers of the dahlia, and the shoots and young leaves of many leguminous plants. It forms small, hard, inodorous crystals, soluble in 11 parts cold and 5 parts hot water, and when heated with strong acids or alkalies, is resolved into aspartic acid and ammonia. It forms certain definite compounds with acids.

ASPARTIC ACID (**Asparaginic** or **Amino-Succinic Acid**) ($C_4H_7NO_4$ or $CO_2H.CH(NH_2).CH_2.CO_2H$)—A colourless crystalline body contained in beetroot molasses, and found among the products of the decomposition of proteids by hydrolysis. It also results from the hydrolysis of proteins and asparagine.

ASPERGILLUS—A genus of small fungi or moulds constituting active agents in the decay of various substances and utilized in some industrial

ASPERGILLUS (*Continued*)—
processes, four large Japanese industries—viz., rice wine, soy sauce, soy cheese, and *shochu* (a distilled alcoholic liquor) being, for example, dependent upon the use of the fungus *Aspergillus oryze,* which give rise to the enzymes protease and amylase employed in their manufacture. Citric and gluconic acids are among the products of the action of *Aspergillus niger* upon carbohydrates. (See Alcohol, Amylo Process, and Fungi.)

ASPHALT—Natural solid or semi-solid bitumen, black or brownish-black deposits of which are found in many places, including Alabama, Trinidad, Alberta (Canada), India, San Valentino, Chieti (Italy), Java, Cuba, Seyssel (on the Rhone), Texas, Utah, Val de Travers (near Neuchatel), Venezuela, and Limmer (near Hanover). They are supposed to have been formed from high-boiling mineral oils by chemical changes including oxidation, melt at from 32° to 100° C., are combustible and largely soluble in carbon disulphide, naphtha, and turpentine. These deposits are known under a great variety of names, including glance-pitch, gilsonite, grahamite, manjork, etc. Various refined forms are used for lining water-tanks, in the construction of asphalt pavings, for binding road materials, for waterproofing, and as components of binding materials, cements, insulating agents, paints and varnishes. Worked up with clay and water in suitable proportions, asphalt is now used for introduction into paper pulp or fibre-board by intercalation, thus increasing the strength and rendering such articles and cartons waterproof and much more durable.

The bituminous constituents of asphalt, which are insoluble in petroleum, closely resemble coal in character, and are termed *asphaltenes*. The content of asphaltenes ranges from 0·25 per cent. in Grosny petroleum free from paraffins to 32·3 per cent. in solid petroleum pitch, the composition being C = 85·5 per cent., H = 6·8 per cent., O = 7·7 per cent., and some sulphur. They are soluble in aromatic hydrocarbons, carbon tetrachloride, and light petroleum. Natural asphalt and petroleum pitch are colloidal solutions of asphaltenes in tars and heavy oils. They can be separated from adsorbed tar by dissolving in the minimum amount of benzene or chloroform, and precipitation by addition of light petroleum (A. Sachanon, *J.S.C.I.*, 1925, **44,** B, 434). (See also G. M. Green on "The Softening Point of Pitch or Bitumen," *J.S.C.I.*, 1929, **48,** 114 T.)

Certain deposits are found in various parts of the world, consisting of aggregates of finely divided mineral matter with liquid oil or semi-solid asphalt, such as the Alberta sands found along the banks of the Athabasca River. The bitumen obtained from these sands yields 18 per cent. gasoline, 13 per cent. kerosene, and 53 per cent. lubricating oils upon distillation. (See Report by Clark and Blair, No. 18 (W. D. MacLean, Edmonton, Canada).)

In one method of extraction the sand is warmed to 80° C. with a solution of 1 part per 1,000 of sodium carbonate in water and gently stirred, when segregation rapidly occurs. The aggregates of bitumen

ASPHALT (*Continued*)—

ball together, allowing the liquor and sand parts to be drawn off, and the asphaltic material can then be collected and treated as desired. Soap or saponin solutions can be used in place of sodium carbonate. According to a recent report, it has been found that the Alberta sands hydrogenated at high temperature and pressure yields at about 380° C. a light oil amounting to 80 per cent. or more of the bitumen, which can be easily refined to produce a satisfactory gasoline. (See *Canadian Journal of Research,* June, 1930.)

The natural rock asphalt, containing varying proportions up to about 20 per cent. bitumen, is converted into so-called "mastic" by melting with a quantity of purer bitumen or a mixture of pitch and mineral oil, so that the product melts at about 76° C. In this form, and in further admixture with sandstone, powdered limestone, or other suitable material, it is used for making pavings and damp courses of buildings. (See "Some Analyses of Asphalt Pavings," by C. T. Kingzett, *J. Soc. of Public Analysts,* December 13, 1882.)

The Trinidad Lake pitch contains about 40 per cent. asphalt, mixed with clay, mud, vegetable matter, etc., and after refining it contains about 50 per cent. and 43 per cent. mineral matter with a little water. In 1923, 41,910 metric tons were exported from Trinidad.

The air-blown bitumens are obtained by blowing air through residual oils at a high temperature, whereby condensation products result, varying in consistency from semi-liquid to solid, better-known types being known as "Hydrolene" and "Texaco." (See J. W. Craggs, *C.T.J.*, 1926, **78,** 390.)

Asphaltic bitumens free from tar products present advantages for paving purposes, as phenol, naphthalene, and acridine are dangerous to fish life in the streams into which the drainage from tarred roads may find access.

Bitumen can be prepared in an emulsified form by several methods—viz., by working up a mixture of it with fatty acids or resin, or both, in an alkaline solution, using agitation. Or it can be dissolved in a suitable solvent like benzol and then emulsified with soap and water. Such preparations have been advocated for application to the surface of roads: among them one is known as "Cold Chon." (See G. B. Chilvers on "Cold Emulsions for Road-work" (*C.T.J.*, 1928, **83,** 163); asphalt emulsions as the subject of papers by Gräfe and Fleck (*B.C.A.*, 1930, B, 542); L. Kirschbraun (*Chem. and Metallurgical Engineering,* N.Y., of which an abstract is given in *C.T.J.*, 1929, **85,** 341); E. S. Ross (*J.S.C.I.*, 1929, **48,** 112 T), and J. Miscall (*Chem. and Ind.*, 1930, **49,** 476).)

"Acid-Resisting Asphalt and its Various Uses in Chemical Industries" is the subject of an article in the *C.T.J.*, 1930, **86,** 375, and report of a paper by J. S. Jackson (*C.T.J.*, 1930, **87,** 503).

"The Chemistry of Bituminous Highway Construction: Native Asphalts" is the subject of a paper by J. S. Miller (see *Chem. and Ind.*, 1929, **48,** 782), who shows in a table the differences in the characters of various asphalt cements (Mexican, Venezuelan, Ber-

ASPHALT (*Continued*)—
mudas, and Trinidad) as employed for paving purposes—that is to say, physical differences which must be related to chemical differences. See also "The Principles of the Manufacture of Mastic Asphalt," by A. W. Attwooll (*J.S.C.I.*, 1930, **49,** 181 T); "Some Applications of Mastic Asphalt in a Chemical Works," by D. McDonald (*Ibid.*, 187 T); "Bitumens as Paint Constituents," by W. N. Bowran (*C.T.J.*, 1931, **88,** 379); "Determination of Bitumen in Asphaltic Materials," by D. M. Wilson (*Chem. and Ind.*, 1931, **50,** 599); P. Hubbard on "The Chemistry of Bituminous High Construction" (*J.S.C.I.*, 1929, **48,** 108 T); D. M. Wilson on "The Bitumen Penetration Test" (*Chem. and Ind.*, 1932, **51,** 203); *Asphalts and Allied Substances*, by H. Abraham (Crosby Lockwood and Son); Gilsonite, Tar, and Torbanites.

So-called "British asphalt" is made from a mixture of sand from chalk deposits, with gas-pitch and tar oil.

ASPHALTENES—See Asphalt.

ASPHYXIANTS—Chemical substances which produce suffocation. Fire extinguishers which depend upon the production of gas, such as carbon dioxide, are sometimes termed "asphyxiators." (See Gassing.)

ASPIRATOR—An arrangement for aspirating a current of air or other gas by suction through a liquid. Another device for separating granular substances by a current of air passing through a thin stream of the substances is described by Bates and Bodnar (*B.C.A.*, 1928, B, 1110). (See Siphon.)

ASPIRIN or ACETOSAL (Acetyl-Salicylic Acid) ($C_9H_8O_4$ or $C_6H_4.COOH.O.CO.CH_3$)—A white crystalline powder of m.p. 132° to 135° C., made from salicylic acid (which exists in meadowsweet) by acetylation, and used as an intestinal antiseptic and for other medicinal applications; soluble in alcohol and ether, but only slightly soluble in water. For a description of its manufacture see *Ind. Chem.*, 1929, v., 277.

ASSAYING—The art of chemically determining the several amounts of metals contained in minerals, ores, alloys, and metallurgical products.

ASYMMETRY—The want of symmetry in atomic arrangement. (See "Dissymmetry and Asymmetry of Molecular Configuration," by Mann and Pope (*Chem. and Ind.*, 1925, **44,** 833 and 1225); and J. D. Main Smith (*Ibid.*, **44,** 1107); also Symmetry.)

ATACAMITE—See Copper.

"ATERITE"—A nickel-brass alloy of acid-resisting character of which valves can be made for superheated steam to withstand 250 pounds pressure and 700° C.

ATM (ATMOSPHERE)—Unit of atmospheric pressure. (See Barometers.)

ATMOLYSIS—The separation of admixed gases by means of a porous partition such as burned clay, dependent upon their relative diffusibilities. (See Diffusion and Gases.)

ATMOSPHERE—See Air.

ATOMIC HEAT—See Heat.

ATOMIC NUMBER—See Atoms, Electrons, and Elements (table, p. 304).

ATOMIC VOLUME—The atomic volume of an element is the atomic weight divided by its specific gravity. (See Elements.)

ATOMIC WEIGHTS of the chemical elements, representing the numbers of the smallest masses that can take part in chemical changes relative to the smallest weight of hydrogen that can similarly function, when hydrogen is taken as the standard because it is the lightest known substance. (See *J.C.S.*, 1931, p. 1617; Atoms, Chemical Interactions, and Elements.)

ATOMICITY—See Valences.

ATOMS are generally described as indivisible and regarded as the smallest parts of chemical elements that can exist in a state of combination or take part in a chemical change. In the past, it was supposed that all the atoms of any one element are of the same size and weight, differing from those of all the other elements in mass (weight) and chemical properties. Hydrogen is the lightest in weight, while oxygen is sixteen times heavier than hydrogen, and these relative weights are termed their atomic weights.

There are various methods of determining atomic weights, some being based on purely chemical relations of the elements, others on volumetric relations, their specific heats and isomorphism respectively, while that based upon vapour densities is of a fundamental character.

The later physical methods used for ascertaining the so-called atomic numbers, as referred to further on, may also be regarded as confirmative of the chemical determinations, leaving the so-called *isotopes* for the moment out of consideration.

The results of recent researches respecting atomic structure are based largely on X-ray analysis and spectrum analysis. Sir J. J. Thomson views the hydrogen atom as consisting of a nucleus whose mass is almost that of the whole, with unit positive charge, around which a single electron moves in an orbit; and it is conjectured that atoms of the different elements have all the same general type of structure, consisting of positively charged nuclei (protons) surrounded at a distance by distributed electrons or charges of negative electricity, the normal (atomic) weight being equal to the number of unit positive charges in the nucleus which makes them electrically neutral. The atomic number of an element represents the nuclear charge of its atom expressed in protons—that is, the excess of positive over negative charges in the constitution of the atomic nucleus, and also the number of electrons which rotate round the central positive nucleus of the atom, this rotation being in orbits governed by the quantum theory. The hypothesis that all the electrons situated at the same nuclear distance or level are necessarily retained with equal forces is called in question by W. C. Reynolds in his book on *Atomic Structure as Modified by Oxidation and Reduction*. Of the various methods for determining the atomic numbers, the most important consists in deducing them from the

ATOMS (*Continued*)—

wave-lengths of the high-frequency spectra by the application of what is known as Moseley's law. (See Isotopes and Moseley's Law.)

The nuclei ("protons") are supposed to be composed of hydrogen with the addition of negative electrons, and to contain the mass of the atoms—the diameter being of the order of 0·00001 of that of the atom—and the region occupied by the external electrons very large in comparison. Viewed thus, the nuclear charge of the hydrogen atom is one unit of electricity, that of helium two charges, and so forth up to uranium (the heaviest atom) with a charge of 92 units. It is further supposed that the difference between the mass of the hydrogen nucleus as found in other nuclei—namely, 1·000—and the mass of the hydrogen atoms (1·0081) is due to the close packing of nuclei (which are now supposed to contain cells), the vanished mass having assumed the form of energy.

The property of radio-activity is stated to belong to the nucleus, and is exhibited by the emission of a swift α-particle or helium nucleus, which is described as a secondary unit composed of four hydrogen nuclei and two electrons.

Apart from certain exceptions (notably uranium and thorium), the great majority of the atoms are regarded as very stable structures, and the nuclei are held together by such powerful force that only the most concentrated source of energy like the α-particle is effective in attack on them, and when disintegration does take place it is on an exceedingly minute scale.

It is obvious that, subject to this hypothesis, electricity is endowed with the properties of matter, and the so-called elements therefore as systems of electricity, differing in the number of electrons and in their motion relative to each other. Further, it is supposed that if the number of electrons in the atom exceeds the atomic number, it is a negatively charged atom or ion, while, reversely, the atom is positively charged; atoms of the metals becoming electro-positive by the loss of electrons, and non-metal atoms becoming electro-negative by the gain of electrons.

The chemical and physical properties of atoms are thus represented as functions of the number, arrangement, and relative motions of their planetary electrons, whilst their mass and radio-active properties are bound up entirely with the nuclei.

Electron-sharing as a factor in chemical combination is of recent enunciation, but no satisfactory physical mechanism has so far been developed concerning this phenomenon, which apparently affects the valencies of atoms. Thus it is represented that in the oxidation of the amine from which methylethylaniline oxide is derived, the oxygen gains and the nitrogen parts with a half share in two electrons which are held in common, and at the same time the nitrogen valency is increased from three to five.

Rays of positive electricity can be applied to the detection of gases in such small amounts as a few millionths of a cubic centimetre, and when diluted 100-fold with other gases. The gas to be examined is placed in a vacuum tube having a perforated cathode, and the positive

ATOMS (*Continued*)—
charged atoms which penetrate the perforation are subjected to simultaneous magnetic and electro-static deflection, and then made to fall upon a photographic plate. The points of their original impact are drawn out into parabola, and knowing the electronic charge, direct information is stated to be obtained concerning the atomic weight and valency of the substance under examination.

It is reported that Rutherford, by use of the high-speed alpha rays of radium "C," has succeeded in knocking hydrogen out of the atoms of boron, nitrogen, fluorine, sodium, aluminium, and phosphorus, the result being interpreted as showing hydrogen to be an essential part of the nuclear structure. (See Report of Discussion on the Structure of Atomic Nuclei (*Proc. Roy. Soc.*, 1929, A, **123**, 373 and 390, and abstract in *B.C.A.*, 1929, A, 622).)

The observation made by Blackett (with others) at the Cavendish Laboratory has been confirmed by W. D. Harkins, of Chicago, who has (to use the expression of the editorial article in *Chem. and Ind.*, 1930, **49**, 318), "after many years of photographing alpha particles of helium travelling through nitrogen, succeeded in recording one or two instances of a merger of an alpha particle and an atom of nitrogen." Harkins also reports the formation of an unstable atom of fluorine which was soon converted into an atom of oxygen.

The supposition of enormous energy evolution through the disintegration of the chemical elements is regarded by some authorities, including R. A. Millikan, as a "childish Utopian fancy."

The new atomic theory may be regarded as a more or less pictorial view of chemical reactions represented by varying distributions of matter and energy, and practical chemistry is still left just as free as before to deal with atoms as distinct chemical entities. (See R. A. Millikan on "Atomism in Modern Physics" (J. Chem. Society, 1924); Niels Bohr on "Quantum Theory of Atomic Constitution" (*J.C.S.*, 1932, p. 349); J. D. Main Smith's *Chemistry and Atomic Structure* (Ernest Benn, Ltd.); *Basis of Modern Atomic Theory*, by D. Clark (Methuen and Co., London); *Atomic Structure*, by W. C. Reynolds (Longmans, London); *Constitution of Atomic Nuclei*, by G. Gamow (Humphrey Milford, London); *Mechanics of the Atom*, by Max Born, translated by J. W. Fisher (G. Bell and Sons, Ltd., London); *The Electronic Theory of Valency*, by N. V. Sidgwick (Clarendon Press, Oxford); also Chemical Interactions, Elements, Electrons, Isotopes, Matter, Mass Spectograph, Molecules, Moseley's Law, Radio-Activity, Specific Heats, Valency, and Vapour Densities.)

ATROPINE (**Daturin**) ($C_{17}H_{23}NO_3$) is a highly poisonous organic base or alkaloid, isomeric with hyoscyamine, prepared from *Atropa belladonna* ("deadly nightshade"), also from *Datura stramonium*. Its preparation from dry belladonna root is described by Diulius (*B.C.A.*, 1930, B, 439). Both are remarkable for their power of dilating the pupil of the eye, while atropine is used medicinally for the paralysis of the para-sympathetics. It crystallizes in colourless prisms or needles; m.p.

ATROPINE (*Continued*)—

114° to 115° C., and is soluble in water, alcohol, and ether. Belladonna leaves should contain a total quantity of about 0·4 per cent. alkaloids. Preparations of belladonna are used in medicine in the form of tinctures, extracts, and plasters to check excessive secretion and to allay inflammation. By hydrolysis with baryta water, atropine yields tropine ($C_8H_{15}ON$), a white crystalline base of m.p. 62°, soluble in water and ether. (See Belladonna and Belladonna Oil.)

ATTAR OF ROSES (**Otto of Roses**) is obtained by distilling the fresh flowers of small white roses known as "Muscata" and of the red variety called *Rosa damascena* with water, and is made in Bulgaria, France, Turkey, Persia, and India, 3 drachms being obtained from 100 pounds of the flower-petals. The Bulgarian rose is the best for the manufacture of this oil, although the other kinds of varying qualities are used. The distilled oil is pale yellow, of sp. gr. 0·850 at 30° C., ref. ind. 1·460 to 1·465 at 25° C., and rotation $-2°$ to $-4°$ at 25° C. It contains from 70 to 75 per cent. of its odourous constituents—namely, geraniol, nerol, and citronellol. It also contains an odourless substance (stearoptene) to the extent of from 10 to 16 per cent., consisting of a mixture of two hydrocarbons insoluble in alcohol, and which can be frozen out by cooling the oil below 16° C. The odouriferous constituents of the oil are soluble in alcohol. Otto of roses is frequently adulterated with geranium oil, and is chiefly used in perfumery, for flavouring, and preparation of pomades. (Compare Phenyl-ethyl-alcohol.)

ATTENUATION—A term used by bacteriologists to signify the weakening of bacterial life, and by brewers to indicate the weakening of worts by fermentation of the contained sugars; also used by chemists concerning the rarefication or thinning of gaseous bodies. (See Vacuum.)

ATTRACTION—See Chemical Interactions.

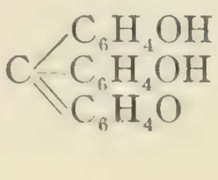
A.U. (**Ångström Unit** = 1 ten-millionth of a millimetre)—See Radioactivity (p. 750) and Wave-Lengths.

AUBEPINE (**Anisic Aldehyde**) ($C_8H_8O_2$)—A colourless liquid of sp. gr. 1·126 and aromatic odour, made by oxidation of anethol; soluble in alcohol and ether, and used in perfumery.

AURAMINE—A dyestuff of the di-phenyl-methane series.

AURIFEROUS—A term applied to ores or minerals containing gold.

AURINE ($C_{19}H_{14}O_3$)—A dye which crystallizes in beautiful green needles and prisms of a metallic lustre, made by heating phenol with a mixture of sulphuric and oxalic acids to a temperature of from 130° to 150° C. Its constitution is shown by the structural formula:



$$C\begin{array}{l}\diagup C_6H_4OH\\ - C_6H_4OH\\ \diagdown\!\!\diagdown C_6H_4O\end{array}$$

"AUSTENITE"—A highly carbonized steel. (See Iron and Rustless Iron.)

AUTOCLAVES—Apparatus for maintaining liquids at any desired temperatures and pressures in chemical laboratories, and constituting important items of chemical plant. (See *Ind. Chem.*, 1928, iv., 4, 81 and 122; A. W. C. Harrison on "The Maintenance and Working of Autoclaves" (*Ind. Chem.*, 1930, vi., 185 and 244); H. Goodwin on *Autoclaves and High Pressure Work* (E. Benn, Ltd.); and Data Sheets.)

AUTOXIDATION—Spontaneous oxidation such as the changes which occur when phosphorus or turpentine are exposed to air or oxygen. Some other bodies not otherwise readily susceptible to oxidation become so in the presence of a third substance—*e.g.*, the production of hydrogen dioxide from water and oxygen when zinc is present. (See Catalysis.)

"AUTROSOL"—An electrically produced liquid preparation of extremely sub-divided carbon and oil, of value in securing engine efficiency in motor-cars, etc. (See "Zollpeer.")

"AVANTINE"—See Isopropyl Alcohol.

AVIATION VARNISHES—See Dopes.

AVOCADO FAT—An edible oil prepared from the fruit of the *avocado* or *aguacate* (Brazilian) pear, and used in America for soap-making. (See Jamieson (with others) (*Oil and Fat Ind.*, 1928, **5**, 202, and *Analyst*, 1928, **53**, 498).)

AVOGADRO'S LAW—See Molecules.

AZIDES—Compounds containing the group—$CO.N_3$ are known as acid azides, and others, such as sodium azide (NaN_3), regarded as salts of hydrazoic acid (azoimides), containing the group $-NN_2$ or $-N_3$. Some of these are used in preference to fulminating mercury as detonators and priming agents, because they require a higher temperature, as a rule, to bring about detonation, and are therefore safer. Silver azide (AgN_3) is a white substance insoluble in water, and can be obtained in fine crystals by dissolving silver nitrate (40 grms.) in water (50 c.c.) and adding the solution to a solution of sodium azide (13·5 grms.) in water (70 c.c.). (See *J.S.C.I.*, 1925, **44**, B, 942.)

H. Kast and A. Haid have given the following temperatures of ignition: cyanuric triazide 205°, lead azide 355° to 360°, mercury fulminate 215°, mercury fulminate chlorate mixture 215°, and lead styphnate 270° C. (See *J.S.C.I.*, 1925, **44**, B, 153.)

In the absence of water, bromine reacts with sodium and silver azides, giving rise to the production of an unstable compound named bromoazoimide (N_3Br). (See D. A. Spencer, *J.C.S.*, cxxvii., 216; also Hydrazoic Acid (Hydrogen Azide) and Lead (Azide).)

AZO DYES—See Dyes and Dyeing.

AZURITE (Chessylite)—See Copper.

BABASSÚ NUT OIL (from *Orbignia martiana*)—From Brazil; has an oil content of 67·2 per cent., with an i.v. of 15·6. It is said to be slowly replacing coconut oil for edible and industrial purposes in Brazil. (See *B.C.A.*, 1929, B, 986; Heiduschka and Agsten, *B.C.A.*, 1930, B, 619; and *Ind. Chem.*, 1932, viii., 35.)

"BABBITT METAL"—An alloy of tin, antimony, and copper, used for bearings, etc. The metal is made of varying proportions of the constituents according to the intended application. One description is given as consisting of 89 parts tin, 7·5 parts antimony, and 3·5 copper, whilst that of "hard" character is said to be an alloy of 83·3 tin, 8·3 antimony, and 8·3 copper. Another of the composition: tin 83 per cent., antimony 10·5 per cent., copper 2·5 per cent., and lead 4 per cent., resists the effects of impact well.

BACTERIA (**Micro-organisms, Microbes**) are microscopic organisms of which the largest is less than $\frac{1}{250}$ of an inch in length, while many require to be magnified thousands of times to become visible. Others, such as that which causes the mosaic disease of the tobacco plant, again, are ultra-microscopical in size and pass through the finest filters, and now more than one hundred diseases are attributed to filter-passers. They abound universally, constituting the simplest and lowest-known forms of vegetable life (fungi), and may be roughly grouped in three categories—viz., the coccaceæ or spherical cells, the bacillaceæ or rod-shaped cells, and the spirillaceæ or thread varieties. They, or some of them, are the indirect causes of certain infectious diseases—that is to say, by the poisons (toxins) they produce under certain conditions which cannot be described with precision, and which appear to vary with individuals. They are also capable of inciting many chemical changes in the nature of fermentations, oxidation, and hydrolysis, possibly by the agency of enzymes associated or produced by them. *B. coli communis* is said to contain a relatively large amount of an enzyme named fumarase.

Cases of food poisoning are alleged to be almost invariably due to bacilli belonging to the Salmonella group. (See *Analyst*, 1926, **51,** 632.) Some which have recently occurred have been traced to the *Bacillus botulinis,* others to bacilli of the Gaertner type, including *B. enteritidis, B. paratyphosus,* and *B. suipestifer,* their presence in foods being evidence of disease in the animals from which the foods are prepared or direct infection of the foodstuffs. The larger number of cases, however, are now attributed to the Ærtrycke type. The Medical Research Council have issued a catalogue of over 2,000 living strains of bacteria and protozoa which affect animals and plants.

It is to be noted that microbes have few and more or less indistinct features by which they can be visually identified: pure cultures of them are difficult to obtain, and they can only be distinguished by functional characters such as the range of temperature or the nature of the medium nutrient in which they will grow; the colour which they will assume or produce in the said medium; the liberation of odours; the liquefaction of the gelatinous or other material on which they are cultivated, etc. Their specificity in precise relations to disease are even more indefinite, because different ones may possibly produce the same or similar products provided the associated material be of appropriate character, and those which, under certain circumstances, are the most dangerous are possibly innocuous in other environments; that is to say,

BACTERIA (*Continued*)—

when not finding an essential soil in which to grow in order to produce the same products.

It has been found, for example, that a minute quantity of silica or calcium salts increases the activity of the tetanus germ, while if silica and calcium salts be absent the germs are harmless. Again the modified alcoholic fermentation produced by *B. coli* is only realized when the organism has been recently grown in presence of free oxygen (aerobically), and the changes induced when employed in connection with glucose yield succeeding series of mixed fermentations (E. C. Grey).

In other words, the action and influence of germ-life depends upon (*a*) the character of the germs themselves, (*b*) the definite nature of the medium in which they exist when entering upon chemical action in the living body, and (*c*) the character of the environment subsequently encountered in the living body.

The experiments of Metchnikoff are generally accepted as having proved that the defence of the living body against the invasion of micro-organisms depends upon the activities of the white cells (leucocytes) of the blood, which are credited with power of concentration and ingestion of the micro-organisms (phagocytosis.) "Opsonins" are described as substances produced by the body cells, and the "Opsonic Index" is the ratio between the number of bacteria thus removed from any sample of blood as compared with that in a normal sample. Immunity from disease, according to one theory, depends upon the presence in the body of substances termed antitoxins or antibodies, which are found in the blood serum after attacks of disease and antagonize the action of invading micro-organisms by making them agglutinate and dissolve (bacteriolysis). (See Savage and White, *Analyst*, 1925, **50,** 239; and Phagocytes.)

So-called vaccines are, for the most part, the sterilized or modified products of cultivations in suitable media of the various bacteria which are regarded as the specific causes of disease, the sterilization being effected by the agency of heat or other treatment, care being taken, of course, to secure freedom from other forms of micro-organisms than those specially concerned. The purpose of so-termed prophylactic vaccine treatment is the production of such an excess of antitoxins in the human system as to constitute a defence against specific infections, each standardized vaccine providing such an excess of antitoxins as to confer neutralization of the several toxins or immunity. (See Vaccines.)

The souring of milk is caused by the *Bacterium lactis*, and that of dilute wine by the *Mycoderma aceti*, etc.

In a suitable medium, the *B. pyocyaneus* produces a blue pigment named pyocyanine, $C_{26}H_{24}O_2N_4,H_2O$, of m.p. 133° C.

Most bacteria are destroyed when heated for a short time to the temperature of boiling water (100° C.), particularly in the presence of moisture, and all of them after a prolonged exposure. They are also readily destroyed by a number of chemical agents, including a solution of corrosive sublimate (1 in 1,000), or by exposure to formaldehyde in

BACTERIA (*Continued*)—

liquid or vaporous form of sufficient strength, or the vapour of sulphur dioxide as generated by burning sulphur candles (particularly when in association with water vapour), and by many disinfectant preparations.

Some kinds have the capacity of surrounding themselves with a protective fatty or waxy sheath—*e.g.*, the *B. tuberculosis*—but lately a method has been devised of defatting and simultaneously killing them.

Many kinds develop by spore-bearing, and the spores are usually more difficult to kill than the fully developed germs.

The activities of bacteria are not confined to organic compounds, such as tobacco, cheese, beer, foods, etc., many changes affecting the earth's surface being due in part to biological influences in which micro-organisms participate. It is alleged that bacteria have been isolated which are capable of converting zinc blende into zinc sulphate. Various iron compounds come within their influence, ferric hydroxide being, for example, precipitated from solutions of ferrous bicarbonate by the action of a group of bacteria, and they are regarded as factors in the natural production of many deposits of ferruginous sedimentary ores. Sulphuretted hydrogen results as a product of decomposition of animal and vegetable matters by saprophytic bacteria, and this, by action on iron compounds, is supposed to be connected with the formation of the "blue mud" of the ocean bottoms.

The power of utilizing the chemical energy of free hydrogen for carbon dioxide assimilation is alleged to be widely distributed amongst bacteria, and *sulphomonas thio-oxidans* has the power of oxidizing sulphur and sulphuric acid. Other anaerobic micro-organisms are capable of reducing sulphates with the production of hydrogen sulphide, and, again, certain sulphides are decomposed by carbon dioxide and fatty acids resulting from bacterial action. Others are capable of oxidizing hydrogen sulphide, leading to the production of sulphates. The most frequently occurring oxidation of hydrogen sulphide is brought about by the higher bacteria—*e.g.*, *beggiotoa*—found in sulphur springs and sewage.

The terms "micro-organisms" and "microbes" are used to cover the entire class of micro-organic forms, all of which are extremely minute living organisms, by whose agency the processes of decay, putrefaction, many fermentations, and other chemical changes are brought about. They are roughly divided into two classes—viz., *aerobes,* which require oxygen for their sustenance, and *anaerobes,* which cannot live in oxygen, and are killed by exposure thereto. The function of anaerobes would appear to be largely in the nature of hydrolysis, and that of aerobes one of oxidation. Many of these low forms of organisms are employed industrially, as, for example, in sewage disposal, brewing operations, vinegar making, tanning operations; the manufacture of acetone, butyl alcohol, hydrogen, citric acid from glucose, preparation of glycerine from sugar, etc.; while in agriculture they come into play respecting the nutrition of plant life, the decomposition of cellulose, the formation of humus, etc.

References: The Relative Bacteriological Actions of Certain Com-

BACTERIA (*Continued*)—

pounds of the Heavy Metals, including Some Cadmium Compounds, by Cooper and Nicholas (*J.S.C.I.*, 1926, **45**, 321 T, and 1930, **49**, 386 T); W. G. Savage, *Analyst*, 1927, **52**, 117; Report of Discussion concerning the Destruction of Materials by Micro-organisms (*Chem. and Ind.*, 1930, **49**, 1437); *A System of Bacteriology in Relation to Medicine*, by various authors, under the auspices of the Medical Research Council (H.M. Stationery Office); *Bacteriology*, by F. W. Tanner (Chapman and Hall); *A Manual of Bacteriology*, by R. T. Hewlett (J. and A. Churchill); *Textbook on Microbiology*, by C. E. Marshall (J. and A. Churchill); *Microbiology* (*Industrial*), by Smyth and Obold (Baillière, Tindall, and Cox); *Bacterial Metabolism*, by M. Stephenson (Longmans, Green and Co.); *The Physiology and Biochemistry of Bacteria*, by Buchanan and Fulmer (Baillière, Tindall, and Cox); Partridge's *Dictionary of Bacteriological Equivalents* (Baillière, Tindall, and Cox); *Sulphur Bacteria*, by D. Ellis (Longmans and Co.); Antiseptics, Disinfectants, Fermentations, Fumigation, Nitrification, Ptomaines, Sewage, Vegetation, and Viruses.)

BACTERICIDES—See Bacteria, Disinfectants, and Germicides.

" BACTEROL "—A proprietary liquid disinfectant containing formaldehyde associated with small proportions of other substances.

" BACTOX "—A powerful germicidal disinfectant made from certain phenoloids and xylenols; miscible with water.

BACURY KERNELS—Seeds of *Platonia insignis*, of the natural order of Guttiferæ, from South America; they yield about 70 per cent. of a fat of m.p. 34·4° C., sap. v. 191·8 and i.v. 63·3.

BADDELEYITE (**Brazilite**)—See Zirconium.

BAGASSE (**Bégasse**)—See Sugar.

" BAKELITE "—The trade name of a material prepared in several forms, a black one being used as a plastic stoving varnish and for insulating purposes. A transparent variety is employed for making various articles and certain vessels used in manipulating hydrofluoric acid (which is without action on it. It is made by condensing equimolecular quantities of phenol and formaldehyde in the presence of a small quantity of a base, and the reaction occurs in two stages: (1) condensation of the two substances in the presence of a catalyst, resulting in the formation of a liquid or viscous product, soluble in alkali, glycerine, acetone, etc.; and (2) transformation of the first product into an insoluble and infusible mass by heating it at a temperature of about 300° to 350° F. under pressure of about 1,500 to 2,000 lbs. per sq. inch of mould surface. Among other applications it is used as a binder for the material of grinding-wheels. In admixture with quartz it has been used for lining pipes in which warm chlorine liquors circulate, and as a homogeneous combination with selected asbestos fibres, named "Haveg," it has found employment as an acid-resisting constructional material in respect of hot or cold hydrochloric acid and many metallic salts.

"BAKELITE" (*Continued*)—

"Haveg" has a sp. gr. of 2·0, a considerable pressure-resisting strength, and can withstand temperatures up to 130° C. It is, however, not stable to caustic alkalies, nitric acid, bromine, chromic acid, etc. The world's output of "Bakelite" was some time since estimated at over 11,000 tons per annum. (See *C.T.J.*, 1925, **77,** 183; Bryson (*Ind. Chem.*, 1925, i., 10, 73 and 145); also Gums and Resins (Synthetic), and "Haveg.")

BAKING INDUSTRIES—Baking powders are preparations used as substitutes for yeast in making bread of a spongy character, by the production of carbon dioxide in the dough. The joint use of tartaric acid and sodium bicarbonate will produce such a result, for example. The use of a baking powder which does not leave any mineral residue, such as acetone dicarboxylic acid which decomposes into carbon dioxide, water, and acetone, is referred to in the *C.T.J.*, 1929, **85,** 488. (See also L. Weil, *B.C.A.*, 1930, B, 391; "Fermentation in the Baking Industries," by David Ellis (*Ind. Chem.*, 1926, ii., 249 and 332); "The Functions of Oils and Fats in Bread-making," by E. B. Bennion (*J.S.C.I.*, 1926, **45,** 435 T); "The Principles underlying Bread-making," by d'Arbouet (*B.C.A.*, 1926, B, 993); Note on "Modern Baking Powders" (*C.T.J.*, 1928, **83,** 526); H. T. S. Britton on "Hydrogen-ion Concentrations in Baking" (*Ind. Chem.*, 1929, v., 160); Calcium (Biphosphate), Fermentations, Potassium (Bitartrate), Wheat, and Yeast.)

BAKOBY OIL—See Tung Oil.

BALANCES—Instruments for the determination of weights made of great variety and some of extreme delicacy. The ordinary form is constructed upon lever principles, and consists of a beam supported at the middle of its length, and suitably connected with weighing-pans suspended from the extremities of the lever beam, with agate knife edges working on agate planes and rider slides traversing the beam. Other things being equal, the longer the arms of the beam the greater is the sensitiveness of the balance.

The assay balance used by the Royal Mint, Royal Arsenal, and Assay Offices is designed to carry 2 grms. on each pan and to turn with 0·01 mg. Another one with "Chainomatic" attachment secures a sensitivity of 0·0001 grm. without weights or riders below 0·1 grm., a length of fine chain attached to the balance beam taking the weights below that figure.

There are so-called micro-balances of very sensitive character, as, for example, the American-made "Ainsworth" micro-balance, which is, of course, enclosed in a case, and in which check weighings have been made to ± 0·002 mg. under severe conditions. The zero point of the balance remains within the limits of ± 0·005 mg. as long as the temperature of the room remains constant within ± 0·5°. The capacity is 20 grms., length of beam 130 mm., and length of pointer only 100 mm. with a 0·5 mg. rider, the weights being from 1 to 500 mg., which are handled by a patented automatic device; 0·1 mg. causes

BALANCES (*Continued*)—

a pointer deflection of only 2·5 scale divisions, and this is magnified by a reflected beam of light, so that one division on the light scale represents 0·004 mg.

An "ultra-balance" provided by Herr Kuhlmann is stated to weigh up to 20 grms., and sensitive to the ten thousandth part of a milligramme. A more delicately constructed instrument, carrying 1 to 2 milligrammes, will register weights as small as $\frac{1}{500000}$ milligramme.

The micro-balance used by Ramsay and Gray depends for its sensitiveness upon the change in buoyancy of a small quartz bulb suspended in air when the pressure is varied.

The "Aperiodic" balance has an air-damping device for reducing the swing period and is provided with a micro-scale and microscope for accurate reading.

The "Precision Torsoin" balance is specially constructed for the accurate weighing of threads to compute the "denier" and for use in the electric lamp industry and Bang's blood-sugar test.

The "Nivoc" balance has a capacity of 100 grms. in each pan and turns to 0·1 mg.

The value of some of these delicate instruments in chemical work is illustrated by E. J. Hartung (*J.C.S.*, 1925, cxxvii., 2691; 1926, pp. 840 and 1349); a discussion on the advantages and disadvantages of various types is given by L. Ramberg (*B.C.A.*, 1929, A, 785). (See also J. Donau on "A New Micro-Balance" (*Analyst*, 1931, **56,** 342); T. T. Cocking on "A New Sartorius Balance" (*Chem. and Ind.*, 1931, **50,** 696), and Weighing Appliances.)

BALATA—The rubber gum, or coagulated latex of *Mimusops globosa,* a forest tree of the order Sapotaceæ, which grows in British and Dutch Guiana, Venezuela, and elsewhere, known otherwise as the "bully tree." It largely resembles gutta-percha in nature and properties but contains more resin, and finds many similar commercial applications. Its stress strain is inferior to that of rubber and it vulcanizes more slowly. The separation of the resins and their industrial possibilities is the subject of an article by F. Harriss Cotton (*The India Rubber Journal,* October 12, 1929, reproduced in the *C.T.J.*, 1929, **85,** 446).

BALSA—The wood of a tree growing in Ecuador, possessing some advantages over cork in that it can be worked with ordinary wood-working tools, and likely to be useful in a preserved state in cold-storage insulation, having a high moisture-absorbing capacity.

BALSAMS (**Oleoresins**) are natural products consisting of essential or volatile oils admixed with resins, which, in some cases, are supposed to be derived from the oils by chemical changes, including atmospheric oxidation; used in perfumery, varnish making, medicine, etc.

Canada Balsam or **Canadian Turpentine** is produced by *Abies balsamiea,* a conifer which grows in Canada, Virginia, Carolina, etc., and, like all the turpentines, is produced by making incisions in the bark. In common with other crude turpentines, when distilled it yields turpentine oil and leaves resin behind in the retorts. It is a yellowish

BALSAMS (*Continued*)—

viscid liquid, of pleasant odour and bitter taste, soluble in ether, chloroform, benzol, etc.

Copaiba Balsam (**Balsam Capivi**), produced by several varieties of *Coparifera* indigenous in Brazil, Peru, Mexico, and the Antilles, flows from incisions made for that purpose in the trees during rainy weather, and in this form it is a syrupy, oily liquid varying in character and properties according to the species of trees from which it is obtained. By exposure to the air it becomes solid, and is used in medicine, also in preparing lac varnishes and tracing paper. It is soluble in alcohol, ether, chloroform, benzol, and carbon disulphide; sp. gr. 0·940 to 0·990.

Dragon's Blood—A red resin of several varieties secreted by the fruits of a number of palms of the genus *Calamus draco,* indigenous in Sumatra and the West Indies. It has been given an acid v. of 11·2; contains benzoic acid in combination and esters of the alcohol drachoresotannol ($C_8H_9O.OH$); is used variously in the process engraving and litho trades, for colouring mahogany varnishes, in preparing gold lacquers, compounding dentifrices, and staining marble to a red colour.

Friar's Balsam—An alcoholic solution of aloes, benzoin, styrax, and tolu balsam.

Mecca Balsam or **Balm of Gilead** is the produce of the *Balsamodendron gileadense,* a terebinthaceous shrub, native of Arabia Felix. There are several varieties, and the finest quality of fragrant odour is said to exude from the flowers, whilst an inferior quality is obtained from incisions in the branches. It is not much used in medicine now, but in the East it is used as a tonic.

Peru Balsam—A viscid black liquor of pathological character which results from beating the bark and scorching with flame after removing the cork from the trunk of *Myroxylon Pereiræ,* which grows in San Salvador and other parts of Central America known as the Balsam Coast. It has a fragrant odour and acrid taste, and contains from 56 to 66 per cent. of cinnamein, which is itself an oily mixture of benzyl benzoate and cinnamate. There are three varieties (white, dry, black); sp. gr. 1·14 to 1·151; soluble in alcohol and ether, and used in medicine and perfumery.

Storax Balsam (Oriental sweet gum) is the produce from incisions made in *Styrax officinalis* (a shrub growing in the Levant, Palestine, Syria, and Greece). This is known in liquid and solid forms, soluble in ether and hot alcohol, and used in medicine as a stimulating expectorant, also in perfumery, and as a detergent in the form of ointment. The semi-liquid balsam from *Liquidambar orientale* (Asia Minor), known in the U.S.A. as "sweet gum," is a pathological product, and contains over 28 per cent. cinnamic acid ($C_9H_8O_2$). The American storax is derived from *Liquidambar styraxiflora,* found in great forests high up in the mountains of Honduras, and in Louisiana, Florida, and Mexico. (See Styrene and Cinnamic Alcohol.)

BALSAMS (*Continued*)—

Tolu Balsam, a nearly solid, resinous body of aromatic odour used in medicine, and obtained in large quantities from incisions made in the trunks of *Myroxylon toluiferum,* growing in various parts of Columbia and South America. It is stated by A. Rollett to contain free cinnamic acid and toluresinophenol. Upon distillation it yields an oil containing a terpene and the benzoic and cinnamic esters of benzyl alcohol.

A Java sample extracted with various solvents gave fractions soluble in carbon disulphide (28·6 per cent.), ether (2·4 per cent.), strong alcohol (61·6 per cent.), and insoluble residue (7·4 per cent.). (See L. van Itallie (*J.S.C.I.*, 1925, **44,** B, 815); A. Rollett (*B.C.A.*, 1930, B, 623); T. T. Cocking (*Analyst,* 1931, **56,** 673); and Gums and Resins.)

"BALSAM WOOL"—A material prepared from pulp-wood bark and sulphite screenings; flexible, easily handled, resistant to fire and water; used as a heat insulator and as a sound-deadening material in buildings. It is stated to be only exceeded by human hair and sheep's wool in insulating efficiency.

"BANKET"—Siliceous ore containing gold, found in the Transvaal.

BARBARY GUM—See Gums and Resins.

BARBASSU NUT OIL (genus *Orbignia*)—M.p. 26° C., sap. v. 247·7, and i.v. 16·83; the cake contains 11·59 per cent. water, 19·81 per cent. proteins, 40 per cent. carbohydrates, 16·50 per cent. cellulose, and yields 6·50 per cent. oil and 5·6 per cent. ash.

BARBEY IXOMETER—An apparatus for determining the fluidity of oils by the rate of flow, so constructed that a pressure of 100 millimetres of liquid is kept at a fixed temperature of 35° C. Raw colza oil, freshly prepared and drawn off, marks exactly 100° of fluidity by this apparatus.

BARBITONE $(C_2H_5)_2.C(CONH)_2CO)$—Another name for veronal (diethylbarbituric acid); a white crystalline body, of m.p. 182° C., soluble in water, and used as a soporific. There are a number of hypnotics of the barbituric acid series.

BARIUM (Ba) **and its Compounds**—Barium is a yellow, lustrous metal of malleable character and atomic weight 137·3; credited with isotopes of mass numbers 135, 136, 137 (Aston, *Nature,* 1931, **128,** 221); sp. gr. 3·75; m.p., about 658° C. (formerly given as 850° C.); and b.p. 1810 ± 10° (Hartmann and Schneider, *B.C.A.*, 1929, A, 754). Barium sulphate ($BaSO_4$) occurs abundantly in nature in the forms of *heavy spar* or *barytes* in the metalliferous mines of Cornwall, Cumberland, Derbyshire, Devonshire, Durham, Shropshire, Westmorland, and Yorkshire, and in the secondary limestone in many places. Barium carbonate ($BaCO_3$) occurs as *witherite* near Hexham in Northumberland and elsewhere, and a rich seam of very fine quality has recently been found in Force Crag in the Coledale Valley, to the left of the Whinlatter Pass. The home output of barium minerals in 1918 amounted to 66,360 tons.

BARIUM (*Continued*)—

Germany and the U.S.A. rank in order as first and second largest producers of barium minerals (chiefly barytes), but this country possesses the most important witherite mine. (See "Mining and Refining of Barytes" (*Ind. Chem.*, 1925, i., 213; *C.T.J.*, 1930, **87**, 628), and W. Trantom on "The Barium Industry" (*Chem. and Ind.*, 1932, **51**, 5).)

Barium Chloride ($BaCl_2 2H_2O$), a colourless crystalline salt, is obtained by dissolving the native carbonate in hydrochloric acid, just short of neutralization, so that any iron present remains in the precipitated state of oxide, and from the solution, the salt which is very soluble in water, is crystallized out in rhombic tables. It is also made by reduction of barium sulphate to sulphide with carbon, and decomposition of the resulting sulphide with calcium chloride, as shown by the equations $BaSO_4 + 4C = BaS + 4CO$ and $BaS + CaCl_2 = BaCl_2 + CaS$.

In another process, briquettes of barium sulphate, lime, and magnesium chloride, together with lignite, are heated in a reducing furnace for some hours; calcium chloride is first formed, and this reacts with the barium sulphate, forming calcium sulphate and barium chloride, which can then be washed out.

It is used in the leather industry, as a rat poison, and in making boiler compounds.

Barium Sulphate (**Barytes**)—When barium chloride in solution is mixed with a dilute solution of sulphuric acid (H_2SO_4), barium sulphate is precipitated in an insoluble form—$BaCl_2 + H_2SO_4 = BaSO_4 + 2HCl$. It occurs in the forms of finely ground *heavy spar*, of crystal system, No. 4, and sp. gr. 4·3 to 4·7. Both forms are used in the paper, textile, and rubber industries as a filler, also in compounding lithopone, other distinct pigments (including *permanent white* and *blanc fixe*), and for admixture with white lead in paint-making. Blanc fixe used as a base for lake colours does not serve well unless admixed with a proportion of aluminium hydroxide. (See Paints.)

Barium Nitrate ($Ba(NO_3)_2$) is obtained by dissolving *witherite* in dilute nitric acid. It crystallizes in large colourless octahedra; is soluble in water, but not so soluble as the chloride, and is used in pyrotechnics for making "green fire."

Barium Sulphide (BaS) is a yellowish-green substance, soluble in water, sometimes used as a luminous paint, as it possesses, in common with calcium sulphide (CaS), the property of emitting a feeble phosphorescent light in the dark. It is also severally used as a depilatory, in vulcanizing, and for weighting gutta-percha. It is commercially prepared from barium sulphate by reduction with coal powder in suitable ovens, and subsequent leaching of the reduced mass with water, which yields a solution really consisting of barium hydrosulphide and some hydroxide. The product yielded upon evaporation is used in making lithopone. Its manufacture in reverberatory furnaces is described in the *C.T.J.*, 1926, **79**, 365.

BARIUM (*Continued*)—

Barium Oxides—There are three oxides of barium—white insoluble bodies—viz., the monoxide (BaO) and dioxide (BaO_2), the last named of which is used as a bleaching agent and in the manufacture of hydrogen dioxide; while BaO_3 appears to be produced by the action of hydrogen peroxide in excess upon a solution of barium hydroxide below 20° C. (M. Carlton). When the monoxide is slaked with water it gives rise to the formation of the hydroxide (BaH_2O_2), which is fairly soluble in hot water, can be obtained in crystalline form, and is used in the sugar industry and oil refining.

Barium Acetate ($Ba(C_2H_3O_2)_2H_2O$)—A white crystalline salt, soluble in water, used as a chemical reagent.

Barium Aluminate ($BaAl_2O_4$)—Made by roasting a mixture of barytes, bauxite, and coke, followed by extraction with water; is useful as a water-softener for boiler supplies. (See R. Stumper, *B.C.A.*, 1930, B, 219.)

Barium Carbonate ($BaCO_3$)—A white compound insoluble in water, prepared from barium sulphide by action of sodium carbonate. In the form of a paste (with or without liquid extract of squills), it is regarded as one of the most effective poisons for rats. A mixture, largely used in India, is prepared from:

Barium carbonate	6 ounces.
Common salt	¼ ounce.
Wheat flour	4 ounces.
Pea or bajri flour	12 ,,
Dripping or ghee	4 ,,

This quantity is sufficient for 1,000 baits. The dripping or ghee is melted, and the whole mixture worked into a paste or dough, rolled out, and cut up into small squares.

Barium carbonate is also used in the china and porcelain manufactures.

Barium Caseinate is a good wetter. (See Wetters.)

Barium Chlorate ($Ba(ClO_3)_2,H_2O$)—White, crystalline, soluble in water, and used in pyrotechnics and dyeing.

Barium Chromate ($BaCrO_4$)—A heavy, yellow, crystalline body, insoluble in water, still used to some small extent in compounding pigments and making safety matches.

Barium Cyanide ($Ba(CN)_2$)—White, crystalline, soluble in water and alcohol; used in metallurgy.

Barium Fluoride (BaF_2)—A white powder, slightly soluble in water, used in enamel-making.

Barium Bromide ($BaBr_2,2H_2O$)—A crystalline salt soluble in water, used in making other bromides.

Barium Manganate ($BaMnO_4$)—Insoluble in water, and used as a pigment.

BARIUM (*Continued*)—

Barium Sulphocyanide ($Ba(SCN)_2.2H_2O$)—A white, crystalline, poisonous body, soluble in water, used in making some other sulphocyanides, etc., is marketed of 95 per cent. strength.

All the soluble salts of barium are poisonous.

BARK—The outer rind of trees, the principal ones being the cork-bark (see Cork), the oak bark used in tanning, and the Peruvian bark from which quinine, etc., is prepared.

BARLEY—See Malt.

BARM—Mixture of wort and yeast; the name is given also to the yeasty top which forms on fermenting beer, used as leaven in bread-making and for other fermentations. (See Beer and Yeasts.)

BAROMETERS—Instruments devised for indicating the pressure or density of the air, of which the "Fortin" is one of the most recent good types. They are made in various forms, of which the simplest consists of a straight glass tube closed at one end, filled with mercury, and inverted with the open end in a tray of mercury. It is generally assumed that the average ordinary density of the air is when, at sea-level and at a temperature of zero (0° C.), the column of mercury in the tube stands at 760 millimetres, or 29·92 inches high. As the pressure or density of the atmosphere increases the column rises, and as it diminishes the column falls. The normal pressure is about 14·7 pounds to the square inch, or 1,012,630 dynes per square centimetre.

The space above the mercury, in the simplest form of a mercurial barometer, is popularly known as the Torricellian vacuum.

As the barometer measures the weight of the superincumbent air, it necessarily follows that the higher the altitude the lower the barometer indication. In chemical investigations, gases are weighed or measured subject to the atmospheric pressure, and as their volumes vary according to temperature and directly in density and inversely in volume with the pressure, the necessity arises of recording the pressure and reducing the amount to a standard pressure and a standard temperature respectively.

Aneroid barometers are constructed without the use of liquids, and are dependent upon the effect of atmospheric pressure on the elastic sides of an exhausted metal box. The barograph is constructed on this principle, and is provided with clockwork and a driven pen, which records the variations of pressure upon a chart.

BAROSCOPE—See Densi-Tensimeter.

BARRILLA—Impure sodium carbonate, somewhat like kelp, produced in Spain and the Levant by burning certain plants (genus *Salsola*), which grow on the seashore, to ashes.

BARWOOD (**Camwood**)—An African red dye-wood from the *Baphita nitida*, which contains 23 per cent. of red colouring matter soluble in hot alcohol, supposed to be identical with "santalin" (a crystalline red body obtained from sandal wood). (See Sandal Wood.)

BARYTES (Heavy Spar)—See Barium (Sulphate).

BARYTOCALCITE—A mineral compound carbonate of barium and calcium of the composition $BaCO_3,CaCO_3$.

BASALT—A dark-coloured fusible form of felspar of volcanic origin, harder than granite, from which apparatus of high acid-resisting quality may be manufactured. It contains about 50 to 60 per cent. silica, 10 to 15 per cent. alumina, and small proportions of iron oxide, lime, soda, potash, and magnesia. It can be melted and cast at about 1,400° to 1,500° C., and is not disintegrated by the electric current, thus admitting of its use for making high-tension insulators, etc. (See *C.T.J.*, 1926, **78**, 318.)

BASE EXCHANGE—See Clays, Water Softening, and Zeolites.

BASES (Alkalies)—Bodies which ionize in solution forming hydroxyl ions, or which combine with acids, thereby neutralizing them and forming salts. Originally, potassium carbonate was obtained from the ashes of seaweed and was called *alkali,* a word of Arabic origin. By the term alkali is now meant something of exactly the opposite nature to acid. The common bases or alkalies include the oxides of potassium and sodium, their hydroxides and carbonates, and ammonia and ammonium carbonate; the alkaline earths and their carbonates.

These alkaline bodies are all more or less soapy to feel when dissolved in water, and they have the opposite action on colours to acids—that is, they turn vegetable red colours to blue colours.

There are many other kinds of bases, all of which have the property of entering into chemical action with acids to form compounds which are called *salts,* including all those organic bodies which are derivatives of ammonia or may be viewed as such, including the amines and the alkaloids.

The term also includes the derivative compounds of the phosphorus, arsenic, and antimony analogues of ammonia; the phosphines, arsines, and stibines being derived by the exchange of hydrogen for radical groups such as CH_3 and C_2H_5 in the compounds known as phosphoretted hydrogen, arseniuretted hydrogen, and antimoniuretted hydrogen respectively; so that there result, for example, triethyl phosphine, $P(C_2H_5)_3$, trimethyl arsine, $P(CH_3)_3$, and trimethyl stibine, $Sb(CH_3)_3$, all of which are of more or less basic character.

A recent definition of a base is "an acceptor of hydrogen nuclei," as illustrated in the case of ammonia by the equations:

$$NH_3 + \overset{+}{H} \rightleftarrows \overset{+}{N}H_4 \text{ and } NH_3 + HOH \rightleftarrows \overset{+}{N}H_4 + \overset{-}{O}H,$$

or otherwise as proton acceptors. (See Acidic.)

BASICITY—The number of hydrogen atoms contained in an acid which can be replaced by a base or metal. (See Acids and Bases.)

BASIC SLAG—See Concrete and Iron.

BASIL OIL—A yellow aromatic oil of sp. gr. 0·945 to 0·99; distilled from the leaves of *Ocymum basilicum;* soluble in alcohol and used in medicine, also for flavouring, soap scenting, etc.

BASSIA OIL (AND FATS)—Obtained from trees of the *Bassia* species, which grow in India and the East Indies, including "Mowrah seed oil," "Illipé butter," "Shea butter," "Njave oil," etc.

BASSORA GUM—See Gums and Resins.

BASSWOOD (LINDEN) OIL—From *Tilia americana;* it is like cotton-seed oil, and contains glycerides rich in butyric acid.

BATHBRICK—Scouring brick made of calcareous and siliceous earth obtained from deposits at Bridgwater and other places.

BATHSTONE—A natural formation of rock chiefly composed of calcium carbonate, and largely employed in the construction of buildings.

BATTERIES (Electrical)—See Electricity.

BATTERIES (Storage)—See Electricity.

"BATTERIUM" METAL—A new anti-corrosive copper-aluminium-nickel alloy of density 7·67, m.p. 1,050° C., tensile strength 35 to 45 tons per sq. in., Brinell hardness 158 to 168. Useful for plant used in respect of organic acids, alkalies, super-heated steam, bleaching, and dyestuff liquors, etc. (See *C.T.J.*, 1931, **88**, 5.)

BATTERY—A stamping mill used in mining.

BAUXITE—See Aluminium.

BAYBERRY (Candleberry)—See Waxes.

BAYER 205 (Germanin)—A colourless water-soluble salt of a complex sulphonic acid, constituting a remedy against sleeping sickness and trypanosomes in animals, and with which Fourneau's 309 preparation is possibly identical. (See article by Dale, under Chemotherapy, p. 180.)

BAY OIL (Myrcia or Bayberry Oil)—A yellowish essential oil distilled from the leaves of the West Indian *Pimenta acris* (*Myrcia acris*); sp. gr. 0·955 to 0·990 at 15° C., ref. ind. 1·510 to 1·520 at 20° C. Yield from 2 to 3 per cent.: used in perfumery and for making bay-rum. It contains pinene, chavicol (a phenol $C_9H_{10}O$), citral, and eugenol.

The essential oil of *Laurus nobilis* produced in Northern Italy from the leaves and containing cineol, is not identical with the myrcia oil. The "Oleum Bacc. Lauri" of druggists is a semi-solid, fatty oil expressed from the ripe fruits of the bay laurel (*Laurus nobilis*), consisting mainly of glyceryl laurate (trilaurin m.p., 45·6° C.).

"BAY SALT" is produced by the evaporation of sea-water.

BEAKERS are thin glass vessels, cylindrical in shape, with flat bottoms, made of such a quality as to withstand exposure to heat, and sometimes provided with a lip to facilitate the transfer of contents. They are of various sizes, from quite small ones up to a capacity of a litre (1,000 c.c.) or more, and are used for holding and heating liquids, and as apparatus in which to effect many chemical operations.

BEAR FAT—The fat of the (Ceylon) bear is brown, and on standing deposits about 30 per cent. stearin. A published analysis gives sp. gr. 0·9146 at 15·5° C., avid. v. 2·31, sap. v. 196·7, i.v. 56·7, unsaponifiable matter 0·69 per cent., and solidifying point 37·7° C.

"BEATL"—Proprietary name of a product the making of which involves the action of formaldehyde on thiourea ($CS(NH_2)_2$); used for the manufacture of tableware, etc.

BEAUMÉ HYDROMETER—See Hydrometer.

BECQUEREL RAYS—See Radio-activity.

BEECHNUT OIL (from *Fagus,* a genus of Cupuliferæ, including a number of species) is stated to contain as follows:

a-Linolenic acid	0·39	per cent.
a-Linoleic acid	9·19	,,
Oleic acid	76·69	,,
Palmitic acid	4·88	,,
Stearic acid	3·45	,,
Phytosterol, etc.	0·82	,,

It is stated to be equal in flavour with olive oil and to keep well, finding domestic use, while the marc is a good cattle food.

BEECHWOOD CREOSOTE—See Creosote (Beechwood).

BEER—Infusion of malt, flavoured with the bitter of hops and fermented with yeast, containing from 2 to 6 per cent. of alcohol. Porter and stout owe their dark colour and special flavour to the employment of added colouring matters or "high dried" malt, but roasted or semi-roasted malts must be used to reach the intense colouration that is desired. Caramel is added mainly for flavouring. Any farinaceous grain can be used, but barley is generally preferred. It is allowed to germinate, and subsequently kiln-dried, converting it thereby into malt, and the higher the temperature at which it is dried the darker becomes the colour. By the process of germination, diastase is formed from the albuminoid part of the grain, and (as explained later) the starch is converted by the diastase into dextrin, malto-dextrin, and maltose, which in their turn are converted into alcohol by the subsequent fermentation with yeast. This, however, is not allowed to proceed to completion, so that some sugar may be left in solution after the yeast is separated from the fermented wort.

While by the action of enzymes a certain amount of ready-formed soluble carbohydrates are formed during the malting process, it is in the mash tun that diastase exercises its fuller function of saccharifying (hydrolysing) the starch of the malt—sometimes supplemented by the addition of other starchy substances, such as maize, rice, or barley—into dextrin, and (according to the active capacity of the enzyme, the measure of modification of the malt, and the temperature employed) into malto-dextrin and maltose. The maltose is reduced by the action of maltase into dextrose prior to the sugar being changed by the ferment zymase into alcohol and carbon dioxide.

There are, it is stated, two distinct diastases, one of which liquefies the gelatinized starch, and the other effects its hydrolysis to the several fermentable sugars. The sugars in the "wort" are accompanied by nitrogenous substances (proteins), which are important, being essential

BEER (*Continued*)—

to the yeast to enable it to perform its work of fermentation and for enhancing the flavour of the beer to be produced. Hops are boiled with the wort in order to give the required bitter character and to preserve the beer from undesirable subsequent fermentative changes. The strength and flavour of the beer admit of endless variation, strong beers containing more alcohol than mild ales, and substantial ones having more "body"—that is, being richer in malt extract.

In making English ordinary beer a yeast is used which rises to the top, whereas in "Lager" or bottom-fermentation beer making, a lower temperature is observed and the yeast sinks to the bottom, the process taking some eighteen to twenty-one days as against five or seven days. Mild or sweet beers are sent out within a few days of brewing, but pale and bitter ales are kept for a longer period before distribution. The character of the water is of great importance, but the presence of sulphates (permanent hardness) is an essential factor in the brewing of pale ales, although soft waters are better for stouts and porter.

Bacteria of the *Acetobacter R.* type are frequently present in beers, and exposure to air always results in formation of acidity, whilst curtailment of air supply enables them to produce mucilage.

When starchy bodies are added as mentioned, they are first of all gelatinised by heating with or without a little malt, in an apparatus styled a converter, thus facilitating the action of the diastase.

The purity of the yeast is of great importance, and much more care is taken now than in former years in scientific brewing to prepare purer cultures, so as to avoid the presence in the beer of those undesirable products which are produced by otherwise associated undesirable ferments.

Brewers' grains have a considerable food value, containing when dry some 20 to about 34 per cent. albuminoids and 30 to 50 per cent. digestible carbohydrates, while the squeezings from the wet grains, containing solids in suspension, have a higher value than the grains themselves.

The average percentage composition of barley (pale ale dried grains) has been given as follows: Moisture 14·9, oil 1·5, proteins 8·6, digestible carbohydrates 67·9, mineral matter 2·6, woody fibre 4·5. Barley yields about one-third of its weight of dried grains.

Sodium hypochlorite or bleaching powder solution can be usefully employed for the disinfection of brewery pipes and utensils. Beer casks are best treated with gaseous sulphur dioxide or calcium bisulphite after washing.

(See articles on the chemical technology of brewing by H. Lloyd Hind (*Ind. Chem.*, 1925, i., 95) on "Hydrogen-Ion Concentration in Brewing," by H. T. S. Britton (*Ind. Chem.*, 1928, iv., 150); "Modern Methods in the Brewing of Beer" (*Ind. Chem.*, 1931, vii., 59); J. V. Eyre (Lecture, Inst. of Chem., 1931) on "Fermentation"; books on *Brewing and Malting*, by J. Ross-Mackenzie and H. G. Wright (respectively) (Crosby Lockwood and Son); Hops, Malt, Ropiness, and Starch.)

BEESWAX—See Waxes.

" BEETLE "—A colourless, transparent, synthetic resin; prepared also in the form of moulding powders for making non-fragile, translucent table ware and other articles, including electrical mouldings. (See Beatl.)

BEET-SUGAR—See Milne, Jones, and Willcox on "Sugar Beet" (*J.S.C.I.*, 1931, 155 T) and Sugar.

BÉGASSE—See Sugar.

" BELCO "—A proprietary cellulose finish.

BELLADONNA (*Atropa belladonna* or Deadly Nightshade, nat. order Solanaceæ)—Both leaves and roots are used in medicine, the chief constituent being an alkaloid named hyoscyamine ($C_{17}H_{23}NO_3$), associated with atropine, the leaves being richer than the root. The total alkaloid content ranges from 0·25 to 0·7 per cent., but this is surmised to partly consist of volatile bases, including methyl pyroline and pyrolidine. The plant is cultivated in England and Germany, and the root is also imported from India. (See E. W. Lewis (*Ind. Chem.*, 1927, iii., 99); Clark and Winter (*B.C.A.*, 1927, A, 504); Atropine and Henbane.)

BELLADONNA OIL is expressed in Wurtemberg from the seeds of *Atropa belladonna,* and used for illumination and other purposes. The poisonous principle is said to be retained in the marc, which therefore cannot be used as cattle food. (See Atropine and Henbane.)

BELLITE—See Explosives.

BELL-JAR—A glass jar of bell shape used for covering other vessels and for other purposes. (See Desiccator.)

BELL-METAL—See Alloys.

BEN OIL—From the seeds of *Moringa pterygosperma*, found in Egypt, Abyssinia, Syria, etc.; recommended as a lubricant for fine machinery. The seeds yield about 48·8 per cent. kernel, which yields over 50 per cent. oil of sp. gr. at 15/15° C. 0·9151; ref. ind. at 40° C. 1·461; sap. v. 188·2; i.v. (Wijs) 71·2.

" BENGAL FIRE "—A mixture of realgar (arsenic disulphide), sulphur, and nitre.

BENTONITE (Wilkinite)—The name given to a group of colloidal clay-like materials or hydrated silicate of aluminium of variable composition found in Wyoming, South Carolina, and other of the U.S.A., as also in British Columbia, New Mexico, and Canada; usually dark, dull, powdery, but waxy on freshly cut surfaces, and varying in colour from yellowish-green to nearly black. They are regarded as products of the changes of volcanic ash and are characterized by an alkaline oxide and alkaline earth content of from 5 to 11 per cent., possess high absorptive power and strong colloidal properties. The bentonite clays are the most colloidal of all varieties, and some of them will absorb more than three times their own weight of water, swelling up and producing a jelly-like mass. Analyses show a content of from 54 to nearly 80 per cent. silica (SiO_2) and 12 to 27 per cent. alumina (Al_2O_3), together with small amounts of Fe_2O_3, CaO, MgO, Na_2O, etc. Wood-

BENTONITE (*Continued*)—
man and Taylor describe Bentonite as a sodium clay liberating sodium hydroxide by hydrolysis in water. (See *J.S.C.I.*, 1929, **48,** 121 T.)

Bentonite has been used in making the plaster known as "antiphlogistine" and as an incorporated ingredient of certain soaps to the extent of from 25 to 30 per cent.; as also a "filler" for felt, paper, etc., as a substitute for fuller's earth in oil bleaching, as a good emulsifier for certain oils, and for the de-inking of paper. Its value, however, as a soap substitute has been called in question.

Ardmonite is the name given to a special variety of clay found at Admore in South Dakota.

Taylorite is an old disused name for bentonite.

The variety used in the paper and oil industries is variously known as *Halloysite* and *Otalite*, and comes from South California, being first dried and then treated with acid before use. (For fuller details respecting bentonite see H. S. Spence, *C.T.J.*, 1925, **76,** 35 and 104; *Ibid.*, 1926, **79,** 560; see also Clays.)

BENZALDEHYDE (C_7H_6O or $C_6H_5.CHO$)—A colourless liquid of high refractive character and almond-like odour, soluble in alcohol and ether, of sp. gr. of 1·05 and b.p. 179° C. Artificial oil of bitter almonds (benzaldehyde) is prepared from benzyl chloride by heating it with water and cupric nitrate, whereby it is hydrolyzed:

$$C_6H_5.CH_2Cl \rightarrow C_6H_5.CH_2:OH;$$

and then oxidized by the copper nitrate:

$$C_6H_5.CH_2:OH \rightarrow C_6H_5.CHO.$$

Chlorination of toluene vapour followed by treatment with sodium hydroxide and oxidation with bleaching powder and sodium carbonate at 40° to 60° C. gives favourable industrial yields of a mixture of benzaldehyde and benzoic acid. (See Schorigin (with others), *B.C.A.*, 1929, B, 934.) It can also be made from toluene by an electro-chemical oxidation process, and a new direct-oxidation process is described in the *C.T.J.*, 1930, **87,** 237. It is used in perfumery, in dyestuffs, and for flavouring purposes. (See J. McLang on "Aromatic Aldehydes" (*C.T.J.*, 1926, **79**, 191 and 307); also Almond Oil (p. 33) and Glucosides (p. 409).)

BENZAMIDE—See Amides.

BENZAMINE HYDROCHLORIDE ($C_{15}H_{21}NO_2HCl$)—An organic compound used in medicine (syn. with eucaine).

BENZAMINE LACTATE ($C_{15}H_{21}NO_2.C_3H_6O_3$)—A white, crystalline compound, soluble in water and alcohol, used in medicine and for the production of eucaine.

BENZANILIDE ($C_6H_5.CO.NHC_6H_5$), m.p. 158° C., distils unchanged and is used in pencils to ascertain if the iron is too hot before ironing clothes, as it leaves a white mark on the sole of the iron if not too hot.

BENZENE (C_6H_6)—A liquid hydrocarbon of cyclic structure (see Chains and Cyclic) with a sp. gr. of 0·8784, and b.p. 80·3° C., obtained from

BENZENE (*Continued*)—

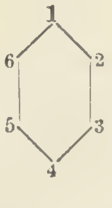
the products of the distillation of coal and from the cracking of certain light-oils. (See G. Egloff, *B.C.A.*, 1929, B, 422.) It is colourless, inflammable, of characteristic odour, soluble in alcohol and ether, and can be prepared in a crystalline state by freezing the pure liquid. It is an excellent solvent of resin and fats, and in crude form (benzol) is extensively used as a fuel for motors, and as a primary material in the manufacture of aniline dyes and many other carbon compounds. Its toxicity as a powerful destroyer of blood corpuscles is a factor that should always be borne in mind by users. There is a demand for benzene free from thiophen. (See Ardagh and Furber, *J.S.C.I.*, 1929, **48**, 73 T.)

Benzene is the initial member of a series of hydrocarbons, and can be obtained pure by distillation of a mixture of benzoic acid and lime. It is the chief constituent of the commercial product known as "solvent naphtha," and admits of sulphonation in the vapour phase. Armstrong (H. E.) is of opinion that there are two distinct forms of benzene.

All the hydrogen atoms in benzene are replaceable by other atoms or groups, and among the many substitution or derived products are monochlorbenzene (chlorobenzene) (C_6H_5Cl), a liquid used in making picric acid and dyestuffs, and dinitrochlorbenzene ($C_6H_3(NO_2)_2Cl$), a crystalline body also used in dyestuffs, etc. *p*-Dichlorobenzene has been advocated as a repellent for clothes moths. (See also Nitrobenzene.)

By carefully controlled partial oxidation, using catalysts, maleic and fumaric acids (which are useful in the dyeing and tanning industries) are produced, and by further oxidation with potassium permanganate it is slowly converted into formic and oxalic acids. Wheeler and his collaborators have shown that benzene can be produced from ethane and also from methane by pyrolysis. (See Benzol and Hydrocarbons.)

BENZENE RING—One of a number of figurative formulæ representing, in this case, benzene as a regular hexagon, in which the carbon atoms are numbered as shown:



According to Armstrong (H.E.) "X-ray illumination to-day enforces the acceptance of the carbon atom in a form nothing short of reality," and no longer to be regarded as a ring, but rather "as a solid, closely packed hexagonal group of six regular tetrahedra, symmetrically arranged face to face." (See also article on "The Riddle of Benzene," by Armstrong (H. E.), (*Chem. and Ind.*, 1929, **48**, 914); Rings, Meta-, Ortho-, and Para-.)

BENZENE-SULPHONIC ACID (Mono) ($C_6H_5.SO_2.OH$)—A crystalline deliquescent intermediate of m.p. about 65° C., soluble in water, alcohol, and ether, prepared by the sulphonation of benzene.

BENZIDINE (**Benzidine Base**) ($C_{12}H_{12}N_2$ or $NH_2.C_6H_4.C_6H_4.NH_2$)—A derivative of diphenyl (para-diamino diphenol), being a greyish-yellow, crystalline, basic body of m.p. 122° C. and b.p. 400° C. (740 mm.). It is soluble in alcohol, ether, and hot water, and is of importance in the colour industry, because the so-called "substantive" colours which dye unmordanted cotton directly can be obtained from it. Congo red and chrysamine belong to this group of colours.

Benzidine is prepared by a reduction process from nitrobenzene in alkaline solution by means of zinc dust, etc.; also by the electrolysis of nitrobenzene followed by distillation.

Hydrazobenzene ($C_6H_5.NH.NH.C_6H_5$) is transformed into benzidine by the action of strong acids, and yields aniline by the agency of reducing agents.

BENZIL (**Dibenzoyl**) ($C_6H_5.CO.CO.C_6H_5$)—A yellow crystalline body of m.p. 95° C., produced by oxidation of benzoin with nitric acid; readily nitrated. Dinitrobenzil ($C_6H_4.CO.CO.C_6H_4(NO_2)_2$) is a pale yellow crystalline body soluble in benzene, chloroform, and acetone.

BENZINE is not synonymous with benzene, but a name indiscriminately used and sometimes given to a light petroleum oil boiling between 120° and 150° C. and chiefly composed of aliphatic hydrocarbons. Persian benzine contains only 2·32 per cent. benzene, and this is associated with toluene, xylene, and many other hydrocarbons. It is used as motor spirit, etc. (See Motor Spirit and Petroleum.)

BENZOIC ACID ($C_7H_6O_2$ or $C_6H_5.CO_2H$) can be obtained in colourless, needle-shaped crystals from gum benzoïn by sublimation, and occurs naturally in the resins named "*dragon's blood*" and "balsam of tolu," although it is chiefly made by the chlorination of toluene, heating the resulting benzenyl trichloride with milk of lime under pressure, and distilling off the benzoic acid. It can also be prepared from benzaldehyde by a process of air oxidation. (For other details respecting its manufacture see *C.T.J.*, 1926, **78**, 187.) It is but little soluble in cold water, dissolves in hot water, and is soluble in alcohol and ether; sublimes readily at 100° C.; m.p. 120° C., and b.p. 250° C. When heated in admixture with lime it is decomposed, benzene and carbon dioxide being produced. It is used in the manufacture of aniline blue, possesses antiseptic and preservative properties, and finds use also in the tobacco industry, perfumery, and in medicine.

BENZOIC ANHYDRIDE ($C_{14}H_{10}O_3$ or $(C_6H_5.CO)_2O$)—A crystalline substance soluble in water and analogous to acetic anhydride; m.p. 39° C.

BENZOIN ($C_{14}H_{12}O_2$ or $C_6H_5.CH(OH).CO.C_6H_5$)—A glistening, yellowish, crystalline body, polymeric with benzaldehyde, of m.p. 134° C., used in medicine, etc. By oxidation with nitric acid it yields benzil.

BENZOÏN GUM—See Gums and Resins.

BENZOL (**Benzole, Solvent Naphtha**)—Commercial product, containing benzene (C_6H_6), toluene (C_7H_8 or $C_6H_5.CH_3$), xylene ($C_6H_4.2CH_3$), etc.

It is a nearly colourless liquid of sp. gr. 0·878, b.p. 80° C., soluble in alcohol and ether, obtained from the distillation of coal-tar and by

BENZOL (*Continued*)—

scrubbing coal gas and coke-oven gas. Its production is favoured by use of high heat in roasting coal and light creosote oil or "tetralin" as liquid absorbent, while activated carbon, silica gel, iron oxide gel, etc., are among the solid absorbents that can be alternatively used. Its vapour exercises toxic influence, and about 90 per cent. of the crude article produced in this country is used as fuel for internal combustion engines. The so-called resinification of unrefined benzoles which occurs during storage is primarily dependent upon the initial autoxidation of the unsaturateds. The stabilization of crude benzol by the addition of small quantities of inhibitors has been studied with considerable success. (See Sixth Report of the Joint Research Committee of the National Benzole Association and University of Leeds; Hoffert and Claxton on "Resin Formation in Benzols" (*B.C.A.*, 1930, B, 1137; and *C.T.J.*, 1930, **86,** 547); C. H. Butcher on "Extraction of Benzol from Coal Gas and Coke-oven Gas" (*Ind. Chem.*, 1930, vi., 51); "Acid Regeneration from Benzol Sludge" (*Ind. Chem.*, 1930, vi., 238); W. A. Voss on "Composition of Benzol from Gas manufactured in Vertical Retorts" (*J.S.C.I.*, 1930, **49,** 343 T); W. H. Hoffert on "Solid Absorbents for Benzol Recovery" (*J.S.C.I.*, 1925, **44,** 357 T; *C.T.J.*, 1925, **77,** 184); Adams, Hoffert, and Claxton (*Ibid.*, 1929, **84,** 541); Hollings and Chaplin (*Ibid.*, 1929, **85,** 593); *Motor Benzole, its Production and Use*, by Hoffert and Claxton (Nat. Benzole Assoc., Ltd.), Benzene, Coal (Colloidal Silica, p. 807), Motor Spirit, Naphtha, and Paints.)

BENZO-NAPHTHOL, or NAPHTHOL BENZOATE ($C_6H_5CO_2C_{10}H_7$) —A white substance, m.p. 107° C., soluble in hot alcohol and used as an intestinal antiseptic, when it splits up into naphthol and benzoic acid.

BENZOYL—The radical group, C_6H_5CO—.

BENZOYL PEROXIDE ($C_{14}H_{10}O_4$ or $C_6H_5.CO.O.O.CO.C_6H_5$)—A crystalline, explosive, oxidizing, and drying agent, soluble in dry toluene; m.p. 106° C.

BENZYL—The radical group, $C_6H_5CH_2$—.

BENZYL ACETATE ($C_6H_5CH_2.C_2H_3O_2$) occurs in several essential oils, and is made from benzyl alcohol and acetic acid by action of strong sulphuric acid; sp. gr. 1·060, b.p. 216° C.; used in perfumery.

BENZYL ALCOHOL ($C_6H_5.CH_2.OH$) may be viewed as methyl alcohol, in which the group C_6H_5 replaces an atom of hydrogen. It is a colourless aromatic alcohol of sp. gr. 1·05, b.p. 206° C., soluble in alcohol and ether, used in perfumery and made by the action of potassium hydroxide on benzaldehyde followed by distillation. It was used during the Great War in making dope (varnish) for covering the fabric parts of aeroplanes, being prepared from toluene by subjection to a current of chlorine gas while in a boiling condition. After purification by distillation, the resulting benzyl chloride is converted into benzyl alcohol by hydrolysis effected by steam in the presence of soda ash. (See Benzyl Cellulose—a new Thermo-Plastic (*C.T.J.*, 1932, **90,** 152, and *Ind. Chem.*, 1932, viii., 62).)

BENZYL ANILINE ($C_6H_5.NH.CH_2.C_6H_5$)—A crystalline intermediate used in the manufacture of certain dyestuffs, prepared from benzyl chloride and aniline; m.p. 33° C.; b.p. 310° C.

BENZYL BENZOATE ($C_6H_5.CO_2.CH_2.C_6H_5$) is a constituent of the balsams of Peru and Tolu, also tuberose oil and Ylang-Ylang. As prepared from sodium benzoate and benzyl chloride, it boils at 196° at a pressure of 25 mm., and is, when pure, white and crystalline, but there is a commercial liquid form, of sp. gr. 1·1224, used in perfumery as a solvent for artificial musk.

BENZYL CELLULOSE—A base for lacquers, enamels, etc. (See Benzyl Alcohol.)

BENZYL CHLORIDE ($C_6H_5.CH_2Cl$)—A colourless aromatic liquid, prepared by chlorinating boiling toluene; sp. gr. 1·1027, and b.p. 179° C.; used for the preparation of oil of bitter almonds and certain dyes. (See Almond Oil and Benzyl Alcohol.)

BERBERINE ($C_{20}H_{17}NO_4.6H_2O$)—A crystalline chelidonium alkaloidal body without marked physiological properties, found present in the bark of *Berberis vulgaris* and the roots of *Hydrastis canadensis*, stated to be identical with chelidoxanthine occurring in *Chelidonium majus*. The hydrated salt is stated to lose $4H_2O$ at 100° C. It is soluble in water, ether, and alcohol; m.p. 145° C. (See Hydrastine.)

BERGAMOT—The yellowish-green, limpid essential oil from the peel of the *Citrus bergamia* (*Citrus aurantium*), which grows in South Europe (chiefly Calabria). The average yield from the fruit is stated to be 0·48 per cent. It contains 35 to 45 per cent. linalyl acetate and terpenes, has a sp. gr. of 0·880 to 0·886 at 15° C.; ref. ind., 1·465 to 1·470 at 20° C.; opt. rot. $+8°$ to $+24°$; used in perfumery, and for flavouring toilet articles and sweetmeats. (See I. Herold, *B.C.A.*, 1931, B, 318.)

BERGINIZATION—Bergius' process for fluidifying coal is briefly described under the subject of coal. According to one account, the crushed coal is mixed with half its weight of coke-oven tar from which the oils distilling below 250° C. have been removed, and there is incorporated in the pasty mass some 5 per cent. of its weight of hydrated iron oxide ("Luxmasse"), to act either as a catalyst or for the removal of hydrogen sulphide from the evolved gases. The resulting mixture, together with an equal weight of pebbles, is then heated by gas jets in a series of bombs rotating at a speed of 60 r.p.m. at 460° to 490° C., while hydrogen gas is pumped in at a pressure of from 200 atmospheres gradually reduced to 60 atm. (See *C.T.J.*, 1927, **80**, 3, and *Ind. Chem.*, 1929, v., 74.) It is stated that only coal the carbon content of which is lower than 85 per cent. (calculated on the ash-free product) is completely amenable to the process, while the presence of sulphur is more or less inimical. The black, tarry, liquefied product yields several fractions upon subsequent distillation between 60° and 300° C. (some 70 per cent. in all), the residue being pitch-like in character.

The younger lignites contain more hydrogen than the older bituminous coals and are consequently more amenable to berginization. With

BERGINIZATION (*Continued*)—

certain varieties of coal it is possible to convert 90 per cent. of it into gas and benzine-soluble liquid (Ormandy).

According to Shatwell and Graham (*J.S.C.I. Abs.*, xliv., B, 434), "clarain" and "durain" parts of coal absorb 3·36 to 3·60 per cent. hydrogen under high pressure at 400° to 436° in presence of phenol, but the "fusain" part is not affected by this process, the phenol appearing to act as a solvent of the hydrogenated products.

Berginization has been tested in respect of various oils and other materials. The German inferior brown coals yield by low temperature carbonization a crude oil from which, by hydrogenation, Diesel oil and motor spirit are obtained, but British coals are not so suitable. An account of the action of hydrogen on coal is given by Graham and Skinner (*J.S.C.I.*, 1929, **48**, 129 T); see also Novák and Hubaick on "Liquefaction of Coking Coal" (*B.C.A.*, 1929, B, 582); J. M. Pertierra on "Liquid Products of the Berginization of Coal" (*B.C.A.*, 1930, B, 974); Reports of the Fuel Research Board for the years ended March 31, 1929 and 1930 (H.M. Stationery Office); H. G. Shatwell (*Chem. and Ind.*, 1925, **44**, 471); H. Nielsen (*J.S.C.I.*, 1926, **45**, B, 652); Sinnatt and King (*J.S.C.I.*, 1925, **44**, 413-424 T); F. Schuster (*B.C.A.*, 1926, B, 115); and H. McGowan (*The Times*, May 22, 1931).

H. E. Fierz-David has shown that when wood, cellulose, lignin, and starch are subjected to distillation under high hydrogen pressure in the presence of nickel hydroxide, the latter substance is reduced to the metallic state at a temperature of 200° C., and the substances in question are wholly changed into tar, water, and gas, the residue consisting of metallic nickel and a small proportion of carbon. (See *Chem. and Ind.*, 1925, **44**, 942; also Synthol.)

From a French source it has been reported that a metric ton of coal gives 200 kilogrammes of gas and from 400 to 500 kilogrammes of liquid, consisting of 25 per cent. phenol and 75 per cent. of a mixture resembling crude petroleum when heated (according to the nature of the coal) to from 400° to 450° C. in hydrogen at a pressure of 150 kilogrammes. From the mixture 80 kilogrammes of petrol can, it is added, be extracted, leaving a heavy oil unsuitable for cracking. (See Coal (p. 212), Hydrogenation (p. 461), Liquid Coal, and Liquid Fuel.)

BERYL—See Beryllium.

BERYLLIUM (Be) **and its Compounds**—Atomic weight, 9·02; sp. gr., variously reported as 1·8 and 1·9; m.p., about 1,285° C. It occurs in a number of minerals, including *beryl* (a double silicate of beryllium and aluminium ($3BeO,Al_2O_3,6SiO_2$), found in Ontario, Quebec, and other countries), of crystal system No. 6 and sp. gr. 2·63 to 2·75, *chrysoberyl* ($Be(Al_2O_3)_2$), and *phenacite* as ortho-silicate (Be_2SiO_4).

There are various types of beryls, varying in constitution from the formula usually assigned—viz., $Be_3Al_2Si_6O_{18}$. An analysis of white beryl from S. Tirol is given by E. Dittler (*B.C.A.*, 1930, A, 57) and T. Uemura has suggested the formula $5BeO,Al_2O_3,4SiO_2$ (*Analyst*, 1928, **53**, 674).

BERYLLIUM (*Continued*)—

Beryl is not appreciably attacked by acids, but suffers decomposition upon fusion with caustic potash; subsequent treatment with dilute sulphuric acid causes the precipitation of silica, and potash alum can be crystallized out, leaving beryllium sulphate in solution, from which the hydroxide can be prepared.

Beryllium is a steel-grey, fairly malleable, brittle metal which cannot be drawn, rolled, or filed, nearly as hard as iron, but said to be really ductile when quite pure. It resembles magnesium in some respects; is soluble in acids; when strongly heated is converted into the oxide (BeO), and in its pulverulent form takes fire upon heating.

The oxide (BeO) is a white infusible solid of sp. gr. 3·0, soluble in acids, and a new patented way of preparing it from the sulphate solution has been described by H. A. Sloman. This method employs, in addition to the crude product, only distilled water, sulphuric acid, ammonia, and hydrogen dioxide, while hydrogen fluoride results as a by-product. (See *J.S.C.I.*, 1929, **48**, 310 T.) A white crystalline, volatile chloride ($BeCl_2$) is obtained by heating the oxide with charcoal in a current of chlorine.

The metal itself can be obtained by heating metallic sodium in the vapour of the chloride, also by the electrolysis of a fused mixture of sodium-beryllium fluoride and barium-beryllium fluoride at 1,350° C. Otherwise the double fluoride of beryllium and sodium mixed with some barium fluoride can be used (see A. C. Vivian, *B.C.A.*, 1926, A, 1114), or, again, a mixture of the fluorides $Na,BeF_2,BaBeF_4$ and Ba,Be_2F_6 (see A. Stock (with others), *J.S.C.I.*, 1925, **44**, B, 924). A still better mixture to use, according to Illig and others, is one of barium fluoride and beryllium oxyfluoride (see *B.C.A.*, 1929, B, 722).

Beryllium is useful as a constituent of light-weight alloys, and a small quantity imparts strength to aluminium. It acts as a useful deoxidizer in copper castings, and in small proportions forms, with nickel and copper respectively, alloys resembling some of the bronzes. Its lightness and its m.p., which is higher than that of aluminium and magnesium, present advantages, but, so far, its cost tells against its extensive employment as an alloying metal.

Many of its compounds, such as the fluorides (BeF and BeF_2), chloride, bromide, sulphide, carbide, sulphate, nitrate, etc., resemble the corresponding aluminium compounds in general character.

The story of its commercial production is given by Kurt Illig (*C.T.J.*, 1928, **83**, 269); see also *Chemistry and Literature of Beryllium*, by C. L. Parsons (Chem. Publishing Co., Inc., N.Y.).

BERZELIANITE—A rare mineral, consisting of copper selenide associated with silver, thallium, and iron.

B.E.S.A.—British Engineering Standards Association. (See Standard Specifications and *Chem. and Ind.*, 1932, **51**, 183.)

BESSEMER PROCESS—See Iron.

BETAÏNE ($C_5H_{11}NO_2,H_2O$)—A colourless, inert, tasteless, crystalline, alkaloidal substance contained in molasses of beet-sugar. (See "Acidol.")

BETA-NAPHTHOL—See Naphthol (Beta).

BETA-RAYS—See Radio-Activity.

BETEL—A mixture of the leaves of the betel pepper, *Chavica betle* or *Piper betel* L. (indigenous to the E. Indian Archipelago and cultivated in India and Ceylon), with the fruit of the *Areca catechu* or betel-nut palm; used in tropical Asia as a masticatory, and in medicine. (See Aseptosol and Catechu.)

BETRATA OIL—The seeds of betrata (*Ricinodendron mahafalense*) are stated to yield 44·64 per cent. of a pale golden oil which makes a good hard soap, and the residual cake is of good quality.

BICHROMATES (Dichromates)—See Chromium Compounds.

"BICHROME"—Trade name for potassium dichromate.

"BIDEFORD BLACK"—A mineral material containing, when mined, roughly about 30 per cent. carbon and 70 per cent. other substances, from which may be prepared, by suitable treatment, a product containing up to 74 per cent. carbon, very useful as a pigment, for use in connection with rubber and cement and the production of black flooring tiles, etc. (See H. M. Langton, *Ind. Chem.*, 1928, iv., 311.)

BILE is the secretion of the liver as discharged into the duodenum, and plays an important part in the process of food digestion. It is a viscid liquid of sp. gr. about 1·02 and yellowish-green colour (which becomes more yellow on dilution), owing its viscidity to the presence of a quantity of mucus derived from the gall-bladder. It consists of more than 90 per cent. water, but the biliary matters proper contain taurocholate and glycocholate of sodium, several colouring matters (the chief of which is bilirubin), also a small quantity of cholesterol, lecithin, and choline.

The bile acids are closely related to cholesterol ($C_{27}H_{46}O$), and possess the same ring system as the sterols. All of them are derived from cholanic acid ($C_{24}H_{40}O_2$).

The following table gives a list of the best-known bile acids:

Name.	Formula.	M.P.	Source.
Lithocholic acid = 3, hydroxycholanic acid	$C_{24}H_{40}O_3$	186°	Man, ox.
Deoxycholic acid = 3, 7, dihydroxycholanic acid	$C_{24}H_{40}O_4$	172°	Man, ox, goat, sheep.
Chenodeoxycholic acid = 3, 12, dihydroxycholanic acid	,,	196°	Man, goose.
Hyodeoxycholic acid = 3, 13	,,	140°	Pig.
Cholic acid = 3, 7, 12, trihydroxycholanic acid	$C_{24}H_{40}O_5$	195°	Man, ox, goat, sheep.

They occur in bile as salts of their amides with glycine or taurine—*e.g.*, glycocholic acid $C_{24}H_{39}O_4(NH.CH_2.COOH)$, which crystallizes in

BILE (*Continued*)—

long needles (m.p. 133° C., freely soluble in hot water; taurocholic acid $C_{24}H_{39}O_4(NH.CH_2.CH_2.SO_3H)$, etc.—both of which are hydrolysed into their constituents by prolonged boiling with alkali. Deoxycholic acid forms well-crystallized additive compounds with fatty acids—*e.g.*, 1-deoxycholic acid-8-palmitic acid, m.p. 186° C., which was formerly called choleinic acid.

The relationship of cholesterol to the bile acids is shown by the fact that the same acid—cholanic acid—may be obtained from both.

Bilirubin ($C_9H_9NO_2$) has a brilliant red colour, but quickly changes to green biliverdin ($C_8H_9NO_2$), when bile is exposed to the air. Another colouring matter is bilifuscin ($C_9H_{11}NO_3$). It is the bile that gives colouring matter to the fæces. (See Fischer and Lindler, *B.C.A.*, 1927, A, 261.)

BINDERS—See C. J. Goodwin, *Chem. and Ind.*, 1930, **49,** 53; *C.T.J.*, 1925, **76,** 635; also Adhesives, Briquetting, and Cements.

BIOCHEMISTRY concerns the composition of the structure, organs, and tissues of the animal body, its various secretions and products, the chemical processes involved in digestion, respiration, the metabolic changes by which nutritive material is built up into living tissues, and, indeed, all the functions of life so far as they are based upon chemical changes, both in respect of physiological and pathological conditions.

With respect to inoculative and other experiments made upon dogs, cats, monkeys, guinea-pigs, rats, mice, etc., it should be borne in mind that the results are not necessarily those which would follow similar experiments upon man.

The Pharmaceutical Society provides facilities for the biological testings of therapeutic substances. (See *Pharm. J.*, 1926, **116,** 205.)

The mineral nutrition of animals forms the subject of an article by W. Godden and A. D. Husband (*Chem. and Ind.*, 1925, **44,** 671) and of an address by J. B. Orr (*Ibid.*, 1925, **44,** 964), in which latter it is pointed out that the inorganic constituents of living tissues, including calcium, phosphorus, potassium, sodium, iodine, fluorine, etc., are indispensable in their several connections with living organisms. Boron in traces has also been found necessary for the well-being of certain leguminous plants. (See also his book on *Minerals in Pastures* (H. K. Lewis and Co., London).)

Although much good work has been done in the last fifty years, further substantial progress in biochemistry necessarily depends very largely upon the acquisition of much more definite chemical knowledge of the composition of the various organs, tissues, secretions, and other parts of the human body.

Many of the subject-matters are treated under various headings in this work, such as Albumens, Air, Bacteria, Bile, Bioplasm, Blood, Bones, Brain-matter, Chyme, Chyle, Feeding-stuffs, Foods, Proteins, Respiration, Toxins, Urine, Vitamins, etc.

Other References: Description of a biological laboratory with illustrations (*Ind. Chem.*, 1930, vi., 277); *The Influence of Chemical*

BIOCHEMISTRY (*Continued*)—

Research on Medicine and Forensic Medicine, by W. A. Willcox (Inst. of Chemistry); F. G. Donnan on "Physical Chemistry in the Service of Biology" (*J.C.S.*, 1929, p. 1387); G. Barger on "The Relations of Organic Chemistry to Biology" (*Chem. and Ind.*, 1929, **48**, 751); H. H. Dale on "Viruses" (*Chem. and Ind.*, 1931, **50**, 827); "Recent Researches on Biological Oxidation," by H. Wieland (*J.C.S.*, 1931, p. 1055); Reports on Biochemistry in the Annual Reports of the Chemical Society, 1929, 1930, and 1931; Kingzett's *Animal Chemistry* Longmans and Co., Ltd.); *Chemistry in Medicine* (The Chemical Foundation, Incor., N.Y., 1928); Thudichum's *Annals of Chemical Medicine*, i. and ii. (Longmans and Co., Ltd.); *Forensic Medicine*, by Sidney Smith (J. and A. Churchill); Pryde's *Recent Advances in Biochemistry* (J. and A. Churchill); Plimmer's *Practical Organic and Biochemistry* (Longmans and Co.); Morrow's *Biochemical Laboratory Methods* (Chapman and Hall); Gortner's *Outlines of Biochemistry* (Chapman and Hall); *Bacterial Metabolism*, by M. Stephenson (Longmans, Green and Co.); *The Materials of Life: A Simple Presentation of the Science of Biochemistry*, by T. R. Parsons (G. Routledge and Sons, Ltd.); *Physiological Chemistry*, by A. P. Matthews (Baillière, Tindall and Cox); *Chemical Embryology*, by J. Needham (Cambridge University Press); other books by Mayer Bodansky (Chapman and Hall); Sumner (Macmillan and Co.).

BIOPLASM, sometimes called protoplasm, is the most elementary living matter in the animal and vegetable kingdoms, being the germinal substance from which all living creatures build up their structures by metabolism. It is mainly of an albuminous character, but contains water and smaller quantities of carbohydrates, fats, etc.

"BIOS"—See Vitamins.

BIOTITE (Black Mica) $[(KH)_2O,(Mg,Fe)_2,O_2Al_2O_3]$—A micaceous hæmatite of crystal system, No. 5, and sp. gr. 2·7 to 3·0. (See Mica.)

"BIRMABRIGHT"—A corrosion-resisting alloy which can be worked in a similar manner to pure aluminium; can be welded autogeneously, and useful for the construction of various vessels and tanks.

BISMARCK BROWN (Triamino-azo-benzene Hydrochloride): $NH_2.C_6H_4.N:N.C_6H_3(NH_2)_2HCl$. A reddish-brown crystalline basic bisazo dye used for leather, furniture, etc.

BISMUTH (Bi) **and its Compounds**—Atomic weight, 209; sp. gr., 9·80; crystal system, No. 3; and m.p., 271° C. Bismuth occurs in nature (associated with traces of sulphur, arsenic, and tellurium) mainly in the metallic state; also combined with oxygen as *bismuth ochre* (Bi_2O_3), of crystal system, No. 4, and sp. gr. 4·36; with sulphur as *bismuth glance* (Bi_2S_3), and with tellurium as *tetradymite* (a natural telluride (Bi_2Te_2S) found in Arizona, California, etc.). It is also found as *bismuth nickel* (Bi_2S_3 with NiS); as *bismuthinite* (a sulphide (Bi_2S_3) occurring in association with gold in Rowan Co., N.C.); as *bismuth-gold* (Au_2Bi) at Maldon, Victoria; as a natural basic carbonate named *bismutite* (of crystal system, No. 4, found in auriferous quartz in the

BISMUTH (*Continued*)—

Transvaal), which yields about 90 per cent. of the oxide Bi_2O_3; also in association with antimony in *kobellite, hauchecornite,* and *chiviatite.*

Bismuth ochre and bismutite are regarded as secondary minerals derived from the primary bismuthenite and bismuth.

It is a lustrous, white, brittle metal of a reddish tinge, obtainable in beautiful crystals, and forms alloys with other metals, of which one of the best known is *Wood's fusible metal,* which melts at 60·5° C. (See Alloys.) Bismuth amalgam is used for the silvering of mirrors.

A pyrophoric form of the metal is stated to be obtainable.

The old process of obtaining the metal direct from the native form by liquation has been largely superseded. As thus made from ores containing from 7 to 12 per cent. bismuth it was sorted out, and after breaking into small pieces placed in iron tubes heated in a furnace, the molten metal running down into a bed of charcoal to preserve it from oxidation and then cast into ingots. The crude metal contains sulphur, arsenic, antimony, copper, nickel, cobalt, silver, gold, lead, and iron; the sulphur and arsenic can be removed by fusion with potassium nitrate and the other impurities by special treatment.

Otherwise, the sulphurous ores are roasted and then smelted with iron, carbon, slag, sodium carbonate, limestone, and occasionally fluorspar, and the regulus obtained in this way further purified from dross by fusion.

The pure metal is obtained by dissolving the crude material in nitric acid, precipitating the bismuth as basic nitrate by addition of water, and reduction with black flux or a mixture of coal, iron, and flux.

Among its compounds are two chlorides ($BiCl_2$ and $BiCl_3$), and two or more oxides, of which the trioxide (Bi_2O_3) alone is of any commercial importance; this is a yellowish insoluble powder of sp. gr. 8·2, prepared by heating the carbonate or nitrate, and is used to replace lead oxide in the manufacture of crystal glass. When acted upon by acids the oxides give salts, including bismuth nitrate ($Bi(NO_3)_3$), soluble in alcohol but decomposed by water, and bismuth sulphate ($Bi_2(SO_4)_3$).

The carbonate as ordinarily prepared by the interaction of ammonium or sodium carbonate and a solution of bismuth nitrate is a mixture of carbonate and bicarbonate, and the precautions to be observed in order to obtain a light precipitate for medicinal use are described by A. J. Jones ("*C. and D.*," August 1, 1925).

Bismuth subnitrate, $(BiO)NO_3,H_2O$, is a heavy white powder insoluble in water; used in medicine and in preparing enamels, fluxes, and cosmetics, made by adding bismuth nitrate to water, which decomposes it, as represented thus:

$$Bi(NO_3)_3 + 2H_2O = (BiO)NO_3,H_2O + 2HNO_3.$$

Bismuth sulphide (Bi_2S_3) is a black insoluble body.

Bismuth trichloride ($BiCl_3$) is a white, crystalline, deliquescent substance, soluble in acids, but decomposed by water forming oxychloride, and employed for fireproofing inflammable materials used for waterproofing.

BISMUTH (*Continued*)—

Bismuth chromate ($Bi_2O_3.2CrO_3$) is a yellow amorphous substance, insoluble in water, used as a pigment.

The bismuth compounds are for the most part insoluble in water, and include many organo-derivatives. Among others used in medicine are the subnitrate, the subcarbonate ($Bi_2O_3.CO_2.H_2O$), the citrate, the betanaphtholate (orphol) ($Bi(C_{10}H_6OH)_3$), salicylate ($Bi(C_7H_5O_3)_3 4H_2O$), a subsalicylate ($Bi(C_7H_5O_3)_3Bi_2O_3$), and the tribromophenylate (xeroform) ($Bi_2O_3(C_6H_2Br_3OH)$.)

BISMUTITE—See Bismuth.

"BISTRE"—A dark brown pigment made from wood soot or peat smoke, and used as China ink.

BISULPHITES—See Sulphites.

"BITALOID"—A proprietary bitumen product prepared as an anti-corrosive enamel solution for application to wood, iron, and steel, and in solid form for lining acid and other tanks, ship's bunkers, etc.

BITTERN—The mother-liquor of sea-water left after crystallization of its salts; formerly used as a source of bromine.

BITTERS are bitter mixtures extracted from vegetable productions, and include quassia, from quassia wood; wormwood, from the herb of that name; aloe, from the juice of the plant; angostura, from bark; orange, from the peel; acorus, from the root of the common sweet flag; cascarilla, from bark; camomile, from the flowers; colocynth, from the fruit (*Citrullus colocynthis*).

"BITULOID"—A colloidal oil for use in coal mines.

BITUMEN—See Asphalt and Tar.

"BITURAL"—A bitumen-like material made in Australia from vertical retort tar by polymerization of its unsaturated hydrocarbons content. It is prepared by digesting a mixture of formaldehyde solution with ammonia of sp. gr. 0·88 and the tar at 150° F. for some hours, after which it is subjected to the passage of hot air. Formaldehyde condensation products are thus formed with the phenols, cresols, and xylols of the tar. The gummy product can be made of any desired consistency and has proved to be a very useful material resembling the softer grades of bitumen. (See *C.T.J.*, 1930, **86**, 568, and C. F. Broadhead (*B.C.A.*, 1931, B, 202).)

BLACK ASH—The crude sodium carbonate as made by the old Leblanc process. (See Sodium (Carbonate).)

BLACK-BAND—See Iron.

BLACK DAMMAR—See Gums and Resins.

BLACK-DAMP—See Carbon Oxides.

BLACKING is commonly made from bone-black, sugar, and oil, with the addition sometimes of a little vinegar or strong sulphuric acid; there are, however, many recipes.

BLACK-LEAD—See Carbon.

BLACKSTRAP—See Molasses.

BLANC FIXE—See Barium Sulphate.

BLEACHING—An operation effected by oxidation or "reduction" of the colouring matters to colourless ones, largely employed in the arts, a number of chemical agents being used therefor.

Bleaching-powder (see p. 126) is used on a large scale, the materials to be bleached, such as calicoes and other fabrics, rags for paper-making, etc., being first steeped in a dilute solution (2 to 2½ per cent. strength) of the bleaching-powder and then in dilute acid. In the case of calico, the fabric is first of all well washed, and boiled successively with lime-water, much dilute sulphuric acid, and weak caustic soda, to remove the weavers' dressing, greasy and resinous matters, etc.

Great care has to be taken in bleaching cloths having coloured strips so as to leave them unaffected, the process calling for scientific attention: the hydrogen ion playing an important part in the problem.

Hypochlorous acid ($HClO$), which may be said to act in the same way (calcium hypochlorite being the active principle of bleaching-powder), also serves the same purposes, readily giving up oxygen. It is, however, a somewhat explosive substance, and undergoes rapid decomposition on exposure to the air. At one time, particularly in France, a solution of sodium hypochlorite was extensively used for bleaching, being prepared under the name of *Eau de Javelle*.

Liquefied chlorine has been much used for bleaching purposes in recent years, the Mathiesen system being based upon the vapourization of the liquid chlorine in a leaden coil immersed in the tank in which the bleaching solution is prepared. (See J. J. Weiss, *B.C.A.*, 1931, A, 572.)

It has been shown that cotton and linen contain two kinds of colouring matter—viz., A, which predominates in America cotton, and B, which predominates in linen; and while A is rapidly bleached by chlorine and more slowly by hypochlorous acid, B is quite unaffected, but is most readily bleached by a mixture containing either some free chlorine or hypochlorous acid and a hypochlorite.

Bleaching by various chemical reagents brings about "tendering" of the yarn or other tissues, the measure of this in the case of bleaching-powder being about 20 per cent.

Sulphur dioxide (SO_2) also exhibits powerful bleaching effects, and is largely used for bleaching straw, woollen and silk goods, isinglass, sponge, and other articles which would be injured by the use of chlorine compounds. To effect this, they have to be moistened and exposed to its fumes as generated by burning sulphur or, alternatively, treated with a dilute solution of the gas dissolved in water (sulphurous acid).

Sodium percarbonate ($Na_2C_2O_6$) gives 120 to 130 grms. of active oxygen per kilogramme, liberating it with regularity, and can be employed in respect of all fabrics to the extent of about 1·5 to 2 per cent. on the weight of the fabric to be bleached without the use of other agents.

Peroxide of hydrogen (hydrogen dioxide H_2O_2) is a very valuable bleaching agent, readily parting with its second constituent atom of

BLEACHING (*Continued*)—
oxygen, and has the great advantage of being perfectly innocuous to operators and goods. It is largely used in respect of delicate fabrics, straw goods, human hair, ivory, etc. The presence of alkaline silicate of sodium increases the efficiency of both hydrogen peroxide and hypochlorite solutions. (See Hydrogen dioxide.)

Permanganate of potassium and other oxidizing agents are also used for some bleaching purposes.

The old practice of bleaching linen and other materials, but particularly hempen and flaxen goods, by exposing them to the air is referred to in the article on Light, and probably results from the production of hydrogen dioxide by sunlight action on moisture and oxygen.

BLEACHING POWDER—See Calcium (Hypochlorite).

BLENDE—Antimony blende. (See Antimony.) And Zinc blende. (See Sphalerite and Zinc.)

BLOOD is built up from the digested food, and serves to supply all parts of the organism with fresh nutrient materials to replace those worn out by the processes of life, and it also dissolves and carries away some of the excretory products. It is alkaline in reaction, and has a sp. gr. ranging from 1·055 to 1·062, its temperature in the living body being about 37·8° C. (100° F.). It is by the medium of the blood that the great process of oxidation through respiration is effected. Besides the other smaller chemical differences between arterial and venous blood there is the greater one in the degree of oxidation, which is dependent upon the oxygen-carrying capacity of the red colouring matter (hæmato-crystalline or hæmoglobin), which contains iron, and consists of a combination of hæmatine ($C_{32}H_{32}FeN_4O_6$) with a certain albuminous substance (globin). The arterial (aerated) blood carries oxygen into the system, whereas the venous blood is loaded with carbon dioxide and other impurities, which are set free in the lungs where the blood is renewed with its new supply of oxygen.

Blood contains seralbumin, fibrin, and globulin in solution, together with a great number of other substances more or less definitely ascertained, in addition to its saline constituents. The clotting of blood is accompanied by an enzyme found therein named thombin, which is variously credited as being either the initiator or accelerator of the coagulation. The serum is that part of the blood which remains liquid after the coagulation of the fibrin which entangles in its meshes (clot) the blood corpuscles. Its content of seralbumin is completely separated (coagulated) by adding a little acetic acid and boiling. The liquid which forms in a blister is a familiar example of serum.

Blood-stains on linen are identified by moistening with a freshly made solution of guaiacum resin in alcohol, and adding a drop of a solution of ether containing 1·2 per cent. hydrogen dioxide, when a blue colour is developed. After removal of the protein the non-protein nitrogen content of blood can be determined by the Kjeldahl process. (See Thudichum and Kingzett (*J.C.S.*, September, 1876), Fibrin, Kjeldahl Process, Phagocytes, and Serum.)

BLOOD ALBUMIN (Seralbumin)—Is prepared from the serum of the blood of animals, and finds use in commerce in connection with printing colours on calico fabrics, also in the leather and other trades, and as a clarifying agent. It is contained in blood to the extent of about 0·08 per cent., the serum itself amounting to about 48·16 per cent.

BLOOD-STONE—A name given in common to a variety of jasper (native silica, SiO_2), and to a kind of red hæmatite.

BLOWN OIL—See Linseed Oil, Oils, and Varnishes.

BLOW-PIPES—Appliances for intensifying the heat of flame by blowing air into admixture with the burning gas. (See Burners.)

BLUBBER OIL—See Fish Oils.

BLUE STONE (Blue Vitriol)—Common names for copper sulphate.

"BLUE VERDITER"—Trade name for basic cupric carbonate.

BOBBINITE—A permitted explosive for use in safety-lamp mines. (See Eversoft.)

BOG-IRON ORE (Limonite)—See Iron.

BOHR'S THEORY is one based upon spectral formulæ and the quantum theory and designed to explain the phenomena of radiation, the architecture of atomic structures, and the irregularities of the periodic system. (See N. V. Sidgwick (*J.C.S.*, T, 1923, **123**, 725); *Theory of Spectra and Atomic Constitution*, by N. Bohr, 1923, and his lecture on "Chemistry and the Quantum Theory" (*J.C.S.*, 1932, pp. 349-384); F. E. Smith's lecture (Inst. Chem., December 18, 1931, p. 11); and Quantum Theory.)

BOILED OIL (Blown Oil)—See Linseed Oil, Varnishes, and Oils.

BOILERS—See Steam and Water.

BOILING-POINT—See Evaporation, Heat, and Vapour Pressure.

BOLE—Various sorts of coloured clays. Armenian bole is of bright red colour; other kinds are yellow or yellowish-red. (See Ochres and Sienna.)

BONE-BLACK (BONE-CHAR)—An impalpable form of carbon prepared by burning bones, and subsequently dissolving out the calcium and other mineral salts by acid applications. The burnt residue before the treatment contains as chief constituents some 10 per cent. carbon finely disseminated throughout a mixture of about 80 per cent. calcium phosphate and about 10 per cent. other mineral matter, and when thus purified is of importance for use in sugar refining and decolourizing various liquids. It appears that the alkaline constituents of the char exert a considerable influence on adsorption of ash from sugar solutions. The constitution of bone-char suggests its possible use as a useful ingredient of animal foods. (See Bones and Carbon.)

BONE FAT is reported to have a sp. gr. at 50°/30° C. of 0·9009 to 0·9034, m.p. 44° to 45° C., solidification-point 32·60 to 33·8° C., sap. v. 189·6 to 195·2, and i.v. (Hanus) 49·1 to 51·6. It is very similar to marrow fat, and yields 19 to 21 per cent. stearic acid, 20 to 21 per cent. palmitic acid, 53 to 59 per cent. oleic acid, and 5 to 10 per cent. glycerol.

BONE-MEAL—See Phosphorus.

BONE-OIL—See Dippel's Oil.

BONES—Dry bones contain about 30 per cent. of ossein, which, when dissolved in water, yields gelatin, and the following table gives the average composition:

Water and ossein	30 to 34 per cent.
Calcium phosphate	45 to 52 ,,
,, carbonate	6 to 14 ,,
,, fluoride	1 to 2 ,,
Magnesium phosphate	0·8 to 1·2 ,,
Other salts	Traces.

The average composition of dry bone after degreasing is: fat 6 per cent., ossein 28 per cent., calcium phosphate 56 per cent., calcium carbonate 8 per cent., magnesium phosphate 1 per cent., and calcium fluoride 1 per cent.

After defatting and extraction of the mineral constituents by action of acids the ossein is left, or it (the ossein) may be obtained by cooking the defatted bones in autoclaves under pressure, and glue is prepared from the exuded ossein. (See Glue.)

Bone-earth (bone-ash) contains about 87 to 88 per cent. calcium phosphate ($Ca_3(PO_4)_2$), 9 per cent. calcium carbonate, 3 per cent. calcium fluoride, and 1·7 per cent. magnesium phosphate. It is used in assaying and some industrial applications.

(See *Bone Products and Manures*, by T. Lambert (Scott, Greenwood and Son, London); also Dentine.)

BORACIC ACID—See Boron Compounds.

BORACITE—See Boron.

BORAX (Sodium Borate)—See Boron.

BORDEAUX MIXTURE—A liquid insecticide and fungicide, used in orchards and vineyards, made as follows:

Copper sulphate	6 pounds.
Quicklime	4 ,,
Water to	25 gallons.

The copper sulphate is dissolved in half the water; the lime is then slaked with the other half and added slowly, with stirring, to the copper sulphate solution. The addition of $\frac{1}{8}$ oz. granulated sugar dissolved in water is stated to stabilize the mixture. It is always applied by spray directed on to the foliage, and is largely used in potato spraying and viniculture.

For protection against scab fungus on apple and pear trees a weaker mixture may be used—viz., 2 lbs. copper sulphate, 2 lbs. lime, and 25 gallons water.

The fungicidal action is due to a hydrated copper oxide, the composition of which varies according to how the mixture is made up, the aim being to get a very finely divided precipitate on the foliage. (See Insecticides.)

BORNEOL, or SOLID CAMPHOR OF BORNEO ($C_{10}H_{18}O$ or $C_{10}H_{17}.OH$) is a secondary alcohol, found in cavities of trunks of old

BORNEOL (*Continued*)—

trees of the order *Dryobalanops camphora* and as a constituent of spruce turpentine. It consists of small, colourless crystals (resembling ordinary camphor and pepper in odour), with a m.p. 208° C. and b.p. 212° C. It is nearly allied to ordinary camphor, from which it can be prepared by the action of nascent hydrogen—$C_{10}H_{16}O + 2H = C_{10}H_{18}O$, while borneol in hexane solution is stated to yield camphor by the action of ozone. It can be synthetically made from *a* pinene. (See J. Schwyzer, *B.C.A.*, 1930, B, 1141.) It is used in medicine and in the celluloid industry. (See Camphor.)

BORNITE—A mineral double sulphate of copper and iron ($3Cu_2S,Fe_2S_3$) occurring in many of the U.S.A.

"BOROCAINE" ($2(C_{13}H_{20}N_2O_2)_4,H_2O.B_2O_3$)—The borate of diethyl-amino-ethyl-para-amino-benzoic acid. A stable, white, crystalline substance, soluble in water, said to be practically non-toxic and the most generally suitable local anæsthetic available, twice as powerful as cocaine, which it satisfactorily replaces, and stated to be free from habit-forming effects. (See *Brit. Med. J.*, September 26, 1925.)

BORON (B) **and its Compounds**—Atomic weight, 10·83 (some experiments show it as 10·825 to 10·847); m.p., 2,200° to 2,500° C. Boron occurs naturally in a number of combinations, one of the best known being *tincal,* a crude borate of sodium or *borax* ($Na_2B_4O_7 10H_2O$) found naturally in the U.S.A., Chile, Peru, Bolivia, Thibet, California, and elsewhere. In combination with calcium, boron is also found in the forms of *boracite* [$Mg_7Cl_2B_{16}O_{30}$(Heinz)]; *colemanite* or *borate spar* ($Ca_2B_6O_{11}$), and as *ulexite* ($Ca_2B_6O_{11},Na_2B_4O_7,16H_2O$)—a compound borate of calcium and sodium found in Nevada and California.

The composition of some borate minerals, as taken from a pamphlet issued by the Imperial Mineral Resources Bureau, is as follows:

	Colemanite. (*California*).	Ulexite. (*Chile and Peru*).	Boracite. (*Asia Minor*).
Boric acid	40·19	44·38	45·89
Lime	31·89	16·14	30·62
Magnesia	1·50	0·91	0·53
Iron and alumina	0·62	0·48	0·98
Soda	—	6·50	—
Sodium chloride	—	7·46	—
Carbon dioxide	8·53	—	—
Sulphur trioxide	0·26	3·35	1·25
Water and organic matter	5·83	16·25	17·09
Insoluble matter	11·18	4·71	3·64
Total	100·00	100·18	100·00

BORON (*Continued*)—

Colemanite is of crystal system, No. 5, sp. gr. about 2·43, and formulated sometimes as $2CaO,3B_2O_3,5H_2O$. It can be used as a glaze material. (See M. M. French, *B.C.A.*, 1932, **51**, 23.)

Ulexite is amorphous, has a sp. gr. of 1·65, and is formulated sometimes as $NaCaB_5O_9,8H_2O$.

Boracite has a sp. gr. of about 3, and is formulated sometimes as $6MgO,MgCl_2,8B_2O_3$, while J. W. Gruner is of opinion that the probable formula is $Mg_6Cl_2B_{14}O_{26}$ (*B.C.A.*, 1929, A, 749).

In the elemental state boron is a soft, greenish-brown powder, but it can be obtained in almost colourless crystals having a density of 2·5, and is stated to be a mixture of two isotopes. The m.p. of boron is about 2,400° C., and it is volatile at the temperature of the electric arc. There are several methods of preparing this element, one of which consists in heating potassium in the vapour of boron trichloride as shown by the equation—

$$3K + BCl_3 = 3KCl + B,$$

and another by heating metallic potassium or sodium in admixture with boron trioxide—

$$6K + 2B_2O_3 = 3K_2O_2 + 4B.$$

The product obtained by heating boric oxide with powdered magnesia is really B_7O, but according to H. K. Kahlenberg (*J.C.S. Abs.* **128,** ii., 425), if boron trichloride formed by passing chlorine over this product be then mixed with hydrogen and passed over a high-tension electric arc between copper electrodes, a deposit of pure amorphous boron is formed.

It is also obtainable in a pure state by the electrolysis of a fused mixture of potassium carbonate, potassium chloride, and boron trioxide, using a carbon anode and a copper cathode.

When heated strongly in the air, boron burns and combines with both oxygen and nitrogen, forming the trioxide and nitride (B_2O_3 and BN).

Boron is sometimes added to metallic castings, especially those of aluminium and nickel, to strengthen them.

The trioxide in a fused state is a colourless vitreous solid which becomes opaque by absorption of atmospheric moisture; it has a feeble acidic character, and, when fused with potassium sulphate, potassium borate is produced, while sulphur trioxide is expelled.

Boric Orthoboric Acid or **Boracic Acid** (H_3BO_3) is found naturally in the water and ‘ Soffioni ” (steam jets) of volcanic eruptions in Tuscany and elsewhere, and is obtained commercially from such sources. It is a white crystalline body, m.p. 184° C.; soluble in water, and in a purified condition finds many medicinal applications, while it is also largely used in glass-making, plating, and metallurgy (as a flux), and as a preservative agent of perishable articles. (See P. Ginori Conti, *C.T.J.*, 1925, **77,** 66.)

Metaboric Acid $H_2B_2O_4$ (or B_2O_3,H_2O) is also known in a solid state,

BORON (*Continued*)—

while Gilbert and Levi have adduced practical evidence for the existence of eight boric acids nB_2O_3,H_2O where $n=1,2,3 \ldots 8$ (Gilbert and Levi, *J.C.S.*, 1929, pp. 527-534).

Sodium Borate (**Borax, Borax Glass**); crystal system, No. 5, can be made from boric acid by adding anhydrous sodium carbonate to a boiling solution of the acid, when the following change takes place—

$$4H_3BO_3 + Na_2CO_3 = Na_2B_4O_7 + 6H_2O + CO_2.$$

That is to say, borax is produced in solution, carbon dioxide is evolved and from the liquid the borax is crystallized out in combination with water ($Na_2B_4O_7 10H_2O$). It is chiefly produced from *colemanite* and the Bolivian deposits of calcium borate by boiling the powdered mineral in water and addition of soda-ash—

$$Ca_2B_6O_{11} + 2Na_2CO_3 = 2CaCO_3 + Na_2B_4O_7 + Na_2B_2O_4.$$

By this reaction calcium carbonate is precipitated and the borax can be crystallized out from the solution, leaving the sodium metaborate ($Na_2B_2O_4$) in solution, and this is afterwards converted into a further quantity of borax by treatment with carbon dioxide—

$$2Na_2B_2O_4 + CO_2 = Na_2CO_3 + Na_2B_4O_7.$$

When colemanite is used, it is first of all calcined in rotary kilns to free it from water of crystallization, and the process of manufacture can be varied by using in the first stage sodium bicarbonate or sesquicarbonate, and in the second stage sodium carbonate and carbon dioxide, in which case the several reactions are represented as follows:

$$2Ca_2B_6O_{11} + 2Na_2CO_3 + 2NaHCO_3 = 3Na_2B_4O_7 + 4CaCO_3 + H_2O$$

and

$$2Ca_2B_6O_{11} + 3Na_2CO_3 + CO_2 = 3Na_2B_4O_7 + 4CaCO_3.$$

When crystalline borax is heated, it loses its associated water and passes into a fused glassy mass ("borax glass"), which possesses the power of dissolving many metallic compounds, so that it is used for analytical purposes, the colour which is communicated to the bead of fused material being indicative of the substance under examination. For example, using a looped platinum wire, it can be made to take up a small quantity of borax, which can then be fused so as to make a clear bead in the loop by heating and dipping afresh in the borax, whilst still hot until it is sufficiently large. If such a bead be touched with a compound of cobalt, it will, upon remelting and subsequent cooling, be found to have an azure or deep blue colour, according to the quantity of cobalt used. Manganese compounds communicate a violet, lilac, or purple colour if the bead be heated in the outer (oxidizing) flame of a blow-pipe; but this colour is lost if the bead be heated in the inner (reducing) flame, owing to chemical changes that occur under these different circumstances. (See Burners.)

Borax is a valuable flux, and is used as a cleansing agent; in making pottery glazes and enamels; also as a glaze for linen and paper, in tanning, in the manufacture of glue, soap, and glass, and as a food

BORON (*Continued*)—

preservative. A new use for it in the electro-welding of wire is described in the *C.T.J.*, 1929, **84**, 4. The volatility of borax is stated to be well established. (See Sodium (Perborate).)

Boron Trichloride (BCl_3), produced by heating boron in a current of dry chlorine, is a mobile, colourless liquid, boiling at a little over 18° C., and is decomposed by water, forming boric and hydrochloric acids.

There is a corresponding trifluoride of boron.

Boron Nitride (BN) is a white amorphous powder, which, when boiled in caustic alkaline solution, is decomposed with the production of ammonia—$BN + 3KHO = K_3BO_3 + NH_3$.

Boron Triethyl ($B(C_2H_5)_3$) is a spontaneously inflammable liquid, and the analogous boron trimethyl ($B(CH_3)_3$) is a gas of very unpleasant character.

Boron Hydrides—Several volatile compounds of boron and hydrogen have been described, including B_4H_{10}, B_2H_6, B_5H_9, and B_6H_{10}. (See paper by Steele and Mills (*J.C.S.*, 1930, p. 74) and Stock (with others) (*B.C.A.*, 1931, A, 50).)

BORT—Crushed diamonds used for lapidary work. (See Carbon.)

BOTTLES are generally made of glass, but some are made of pottery and others of gutta-percha for holding liquids such as hydrofluoric acid, that act upon glass.

BOYLE'S LAW OF PRESSURE—See Gases.

BRAIN-MATTER contains from 80 to 90 per cent. water, the tissue being a mass of colloidal matter of which the envelope is albuminous in character, while the constituent parts are of very complicated constitution, comprising a number of phosphorized substances named variously phosphatides or phospholipins, including lecithin, kephalin, and sphingo-myelin, and another group of galactosides or galactolipins, including phrenosin and kerasin.

Lecithin ($C_{42}H_{84}NPO_9$) upon hydrolysis yields glycerophosphoric acid ($C_3H_9PO_6$), fatty acids—including palmitic, stearic, and oleic acids—and the base choline ($C_5H_{15}NO_2$), while kephalin ($C_{41}H_{81}NPO_{13}$?) gives amino-ethyl alcohol ($NH_2.CH_2.CH_2.OH$) (identical with Thudichum's "oxyethylamine"). The unsaturated acids are probably linolic and arachidonic acids.

Sphingo-myelin upon hydrolysis yields sphingosine ($C_{17}.H_{35}.O_2.N$), as also choline in association with other cleavage products, including lignoceric acid and phosphoric acid.

Phrenosin ($C_{48}H_{93}O_9N$) is a dextro-rotatory gelactoside and can be separated from sphingo-myelin by the use of pyridine as a solvent; upon hydrolysis it yields sphingosine (see above), phrenosinic acid ($C_{25}H_{50}O_3$), and a crystalline sugar named galactose ($C_6H_{12}O_6$) (identical with Thudichum's *cerobose*).

Kerasin ($C_{47}H_{91}O_8N$) is lævorotatory and yields upon hydrolysis the same carbohydrate and lignoceric acid ($C_{24}H_{48}O_2$), accompanied by the base sphingosine ($C_{17}H_{35}O_2N$). (See O. Rosenheim, *Biochem.*

BRAIN-MATTER (*Continued*)—

J., vol. vii., No. 6, December, 1913; vol. viii., No. 2, April, 1914; and vol. x., No. 1, March, 1916.)

Cholesterol ($C_{27}H_{46}O$) constitutes 10 per cent. of the dry brain-matter, and there are also other constituents, including inositol, lactic, and succinic acids, extractive matters, etc.

It is to the classical researches of Thudichum, Kingzett, and his other assistants that the chemistry of the brain is mainly due, and many important additions to this knowledge have been made in more recent years by Rosenheim, Maclean and Levene.

(See Reports of the Medical Officer of the Privy Council and Local Government Board, New Series, No. III., 1874, p. 113, and some following ones: Thudichum's *Annals of Chemical Medicine*, vols. i. and ii. (Longmans and Co.); Thudichum, *A Treatise on the Chemical Constitution of the Brain* (Baillière, Tindall, and Cox, 1884); MacLean, *Lecithin and Allied Substances* (Longmans and Co.); Levene on *Structure and Significance of the Phosphatides* (Physiological Reviews, 1921); also Eggs, Galactosides, and Lecithin.)

BRANDY—Real "spirit of wine" as prepared by the distillation of fermented wines, generally coloured with burnt sugar or caramel, containing varying proportions of the higher alcohols and esters.

BRANNERITE—See Uranium.

BRASSES—Brasses are alloys of copper and zinc, copper preponderating; a prefix is now generally used to indicate any in which a third metal is present, as, for example, tin-brass. "Al-dur-bra" is an aluminium brass. The presence of iron in brass is considered very objectionable. (See "Aluminium Brasses," by R. Genders, *B.C.A.*, 1930, B, 423; Alloys, Bronzes, Copper, and Zinc.)

BRAUNITE—See Manganese.

BRAZILITE (**Baddeleyite**)—See Zirconium.

BRAZIL-NUT OIL—See Castanha Oil.

BRAZIL-WOOD DYES (red and orange), extracted from the wood of the *Cæsalpina crispa* ("Red wood") by boiling water, and used for calico printing and dyeing silk and wool. (See Pernambuco.)

BREAD—Baked dough. (See Wheat.)

"BREMEN BLUE"—Trade name for varieties of specially prepared copper hydroxide or (and) basic copper carbonate. As prepared from copper sulphate solution and sodium hydroxide in certain proportions, it may also contain some basic cupric sulphate ($CuSO_4.3CuO,4H_2O$).

BREWING—See Beer.

BRICKS are made from clay or the mixture of clay and sand called *loam*, as also *marl* (which consists of clay and lime), by moulding and baking. For the inner lining of chemical works-chimneys of an acid-resisting character, vitrified bricks very low in lime content and laid up in acid-proof mortar are used, the mortar being of a nature to resist the particular acid in the smoke stream. They are composed of mixtures of

BRICKS (*Continued*)—
good clay, pure silica sand, kaolin, asbestos fibre, china clay, graphite products, ground gypsum, etc., a common binder being silicate of sodium. Chrome-silica bricks are mechanically stronger at high temperatures than the normal chrome brick, and both have a smaller reversible expansion than silica bricks. "Grog bricks" and the coarser non-plastic constituents of bricks known as "grogs" and "green grogs" are dealt with in a paper by C. R. F. Threlfall (*Chem. and Ind.*, 1930, **49,** 992). Calcium-silicate bricks are made mainly from sand and some 5 to 10 per cent. of slaked lime subjected to heat in an autoclave under pressure of 120 to 180 lbs. per square inch by direct steam. The process is described in the *Ind. Chem.*, 1928, iv., 32. See also Bessey and Lea (*J.S.C.I.*, 1932, **51,** 91 T); Recent Improvements in Brick-making (*Chem. and. Ind.,* 1930, **49,** 212); the "S. u. G." process of making refractory bricks and blocks, by Ackermann and Knuth (*Chem. and Ind.,* 1930, **49,** 497); Setterberg Porous Refractory and Insulating Bricks (*Ind. Chem.,* 1929, v., 422); Some Changes which take place during the Process of Burning Fire-Clay Bricks, by Green and Theobald (*J.S.C.I.*, 1925, **44,** B, 501); Blakeley and Cobb on Testing Heat-Insulating Bricks (*J.S.C.I.,* 1932, **51,** 84 T); Dissolution and Durability of Fletton Bricks, by McHugh and Knight (*J.S.C.I.*, 1932, **51,** 107 T); *Cement, Concrete, and Bricks,* by A. B. Searle (Constable and Co.); and Refractories.

BRIMSTONE—See Sulphur.

BRINE (Salt Water)—According to A. J. Pelling, the brine from the Pretoria salt pans contains on average 0·8 per cent. $NaHCO_3$, 8·2 per cent. Na_2CO_3; 15·5 per cent. NaCl, and 75·5 per cent. water. (See *J.S.C.I.,* 1925, **44,** B, 588; J. E. Teeple on the industrial development of Searles Lake brines (see *Chem. and Ind.*, 1929, **48,** 862; and Water (Sea Water).)

BRINELL BALL TEST for hardness of metals. The measured determination of indentation on prepared surfaces caused by applied heavy weight or blow of steel ball. (See *Mechanical World Year Book,* 1932, p. 276 (Emmott and Co., Ltd., Manchester).)

BRIQUETTING is a process used in respect of many materials requiring no admixture, or possibly only damping; also others which call for the addition of some reagent to become self-cementing, but chiefly those which definitely require a binder. It is also used in machine shops for pressing up metal swärfs (grits), thus lowering transportation and handling charges, time in charging furnaces, etc.

Sutcliffe and Evans have found that certain coals may be formed into strong briquettes without any binder if firmly pulverized and subjected to a pressure of about 10 tons per square inch, but they may become weaker above 220° C. Coal dust may also be briquetted to some extent without the use of any external binding agent by heating to from 400° to 450° C. and pressure. Ordinarily, in preparing fuel briquettes from small or powdered coal or coke many kinds of binding

BRIQUETTING (*Continued*)—

materials are used, and in particular coal-tar, pitch, and resin. A suitable pitch can be prepared from coke-oven or gasworks tar, or from carburetted water-gas tar. The tar from blast furnaces and producer gas-plants yields pitches which are not so suitable.

A specification of a suitable pitch is as follows:

Volatile organic matter	68·70 per cent.
Fixed carbon or Cokes (sintered)	31·24 ,,
	31·30 ,,
Ash	0·06 ,,
Melting-point	84·0° C.

Resin is best not used alone, as the briquettes thus made fall to pieces quickly in the fire, but, used in association with pitch in the proportion of 1 part to 4 or 5 of pitch, its use exhibits advantages over that of pitch alone.

For domestic purposes it is best to employ anthracite with a little bituminous coal, and about 11 per cent. of medium soft coal-tar pitch.

Glue and starch can be used in respect of sawdust and wood waste.

Petroleum residues constitute useful binding material, and where coal is scarce and pitch too expensive, arrowroot and waste starch have been successfully used. The "Thornley" patent binder is one of which the active constituent is derived from sea-weed. Other binding materials include distillers' waste, molasses residue, "pastaccio" (a waste product of the citrus fruit industry), carragheen moss, albuminates, tanning residues, and dried blood. One patented binding material consists of vegetable matter such as grass, reeds, flax residue, sisal hemp waste, etc., prepared by stacking, keeping moistened with a solution suitable for promoting the growth of organisms, and allowing to ferment to a pulpy mass, which is afterwards milled with 2 per cent. of its weight of sodium carbonate. This mixture is not sticky, but its agglomerating and hardening property is developed upon heating the briquettes made with it. (See *C.T.J.*, 1925, **77**, 596.)

In an article on "Briquetting with Smokeless Pulp Binders" (*Chem. and Ind.*, 1930, **49**, 53, and English Patent No. 244,517), C. J. Goodwin has described the preparation of a vegetable binder produced by the humic fermentation of cellulose from soft vegetable waste through the agency of a bacterial food, which is particularly valuable where the use of pitch is economically or technically impracticable. It is stated that ovoids of anthracite, thus prepared, do not soften in the fire, but remain hard and coherent until completely burnt.

The briquetting of sawdust by a French method is described in an article reproduced from the *Engineer* (*C.T.J.*, 1925, **77**, 683); see also Adhesives and Pitch.

BRITANNIA METAL—Used for making domestic table-ware, such as spoons, cans, teapots, etc. Its composition is given under the heading of Alloys, and occasionally 2 or 3 per cent. zinc is incorporated. (See Alloys, Antimony, and Tin.)

BRITISH GUM—See Starch.

BROMINATION—The chemical importation of bromine into the constitution of a substance.

BROMINE (Br) **and its Compounds**—Atomic weight, 79·91; sp. gr. 3·188 at 0° C.; m.p., 7·3° C.; b.p., 63° C.; credited with two isotopes. It is found in sea-water in combination with potassium, sodium, and magnesium—about 66 to 70 parts per million—and more abundantly in certain mineral waters and salt springs. The Stassfurt *carnallite* deposits contain it (combined with magnesium), and from this salt it is chiefly made, while other supplies are afforded by the Dead Sea water and by the electrolysis of residual waste brine of the salt industry.

In the manufacture of potassium chloride from *carnallite,* there is produced a mother-liquor containing about $\frac{1}{4}$ per cent. of bromine as magnesium bromide, and after admixture with manganese dioxide and sulphuric acid, the bromine is obtained by heating it with superheated steam, or by decomposition with chlorine (which replaces it in combination) the bromine being set free in vaporous state and condensed in cooled stoneware coils. Or the bromine may be extracted from concentrated brine, *d* 1·21, by treatment with chlorine after acidulating with sulphuric acid, the liberated bromine being removed by the solvent action of carbon tetrachloride and recovered therefrom by treatment with lime suitably hydrated, the solid product thus resulting yielding all its bromine content upon subsequent treatment with dilute acid. (See C. M. A. Stine, *Ind. and Eng. Chem.*, May, 1929.) Alternatively, after concentration of the sea-water and acidulation with 1 per cent. sulphuric acid, aniline sulphate is added in calculated quantity with the view of producing tribromoaniline. An account of the methods used on the s-s-ethyl is given in the *C.T.J.*, 1929, **85,** 5.

Another process of manufacturing bromine from the Michigan brines is based upon the production of ferric bromide by a process involving the use of bleaching powder.

During the Great War, France obtained a considerable quantity of bromine from salt deposits in the marshes or lagoons of Tunisia by the action of chlorine upon the liquors.

Bromine is a heavy, mobile liquid of a red-brown colour and strong, unpleasant smell; gives off vapour of the same colour when exposed to the air, solidifies at −7° C. to a crystalline mass, is very poisonous, has a strong corrosive action on the skin, and is soluble in water, alcohol, and ether. It is used in the dye industry, in organic synthesis, the production of bromides, and ethyl bromide (for production of tetraethyl lead). Wood and Illing have shown that bromine is as efficient as chlorine for sterilization of water (*Analyst,* 1930, **55,** 125).

The soluble salts, sodium bromide (NaBr), potassium bromide (KBr), and ammonium bromide (NH_4Br), are all used in the preparation of certain medicinal sedative mixtures. (See *C.T.J.*, 1927, **81,** 155, for notes on the Manufacture of Alkali Bromides.)

Hydrobromic Acid or **Hydrogen Bromide** (HBr) (corresponding to hydrochloric acid) is produced when a mixture of hydrogen and bromine vapour is burned or passed over a spiral wire of platinum main-

BROMINE (*Continued*)—

tained at a bright red heat; or by dropping bromine upon wetted red phosphorus, which results in the formation of tribasic phosphoric acid and evolution of hydrobromic acid, and by a number of other methods. It is a colourless gas of pungent colour, which fumes in the air and is very soluble in water, the aqueous solution resembling one of hydrochloric acid in its general chemical behaviour.

Bromic Acid ($HBrO_3$) is only known in solution, and it forms bromates corresponding to the chlorates, by corresponding reactions, potassium bromate having the formula $KBrO_3$.

Bromine Chloride ($BrCl$), according to H. Lux, prepared as described by him, is an ochre-yellow solid body of m.p. $-54°$ C., which rapidly decomposes in the vapour phase (*B.C.A.*, 1930, A, 878).

Bromine Hydrate ($Br_2 10H_2O$). (See I. Harris, *J.C.S.*, 1932, p. 582.)

BROMOFORM ($CHBr_3$)—A colourless heavy liquid; sp. gr. 2·9315 at 0° C., and b.p. 149·55° C. (corresponding to chloroform and iodoform), made by distillation from a heated mixture of ethyl alcohol, bromine, and sodium hydroxide; soluble in alcohol and ether, and used in medicine.

BROMONAPHTHALINE, or MONO-BROMO-ALPHA-NAPHTHALENE ($C_{10}H_7Br$) is a yellow crystalline compound, soluble in alcohol, ether, and benzol, made by the bromination of naphthalene; it melts at 6·2°, boils at 279° C., and is used in organic synthesis.

BROMYRITE (**Bromite**)—Natural silver bromide ($AgBr$), of sp. gr. 5·8 to 6, and crystal system, No. 1, containing 57 per cent. of silver, found in New Mexico and Nevada.

BRONZE BLUES—Forms of Prussian blue.

BRONZE POWDERS—Used for japanning and other decorative applications, and made of many shades; compounded of alloys of various metals—copper, zinc, iron, tin, lead, vanadium, etc.—beaten into leaf and reduced to powder, with or without admixture with other compounds, according to the desired colour and properties. Oxygen in the copper is one of the worst impurities as concerns bronze powders.

BRONZES—By one classification, "bronzes" consist of copper and aluminium only, good bronze containing from 3 to 5 per cent. copper. So-called "steel bronze" contains 8·5 per cent. copper and a proportion of silicon, while "acid bronze" contains about 10 per cent. copper. Bronze M.A. is a standardized non-ferrous alloy prepared to meet the need of a gun-metal and a phosphor bronze, the analysis being as follows: Copper, 85·5 per cent.; tin, 9·96 per cent.; zinc, 1·86 per cent.; lead, 1·83 per cent.; phosphorus, 0·25 per cent.; antimony, 0·24 per cent.; iron, 0·07 per cent.; nickel, 0·04 per cent; and arsenic, 0·06 per cent. Without corresponding to any particular specification, it is said to contain all the elements usually met with in ordinary gun-metal and bronzes. (See French and Staples on "Bearing Bronzes with and without Zinc" (*B.C.A.*, 1929, B, 820); *The Metallurgy of Bronze*, by H. C. Dews (Sir Isaac Pitman and Sons); also Alcobronze (p. 238), Alloys, Aluminium Bronzes, "Coronium," Phosphor Bronze, and Tin.)

BROOKITE (TiO_2,) crystal system, No. 4, and sp. gr. 3·8 to 4·2.—See Titanium.

BROTEX—A hybrid biennial plant of recent origin described as of rapid growth, producing fibre for textiles, cellulose for paper-making, and seed for cattle-cake, having an oil content of 15 per cent. The parentage of the plant is so far kept secret, but it belongs to the order *Malyaceæ*. (See *Empire Forestry Journal,* vol. 8, No. 1.)

BROWN COALS—These, like lignites, are differentiated from the geologically older bituminous coals, inasmuch as (1) in the raw state they contain much more water (varying from 20 to 50 per cent.); (2) by air-drying they usually disintegrate more or less; (3) they are naturally devoid of coking properties; (4) in the dry-ashless state they usually contain more than 75 per cent. carbon and 20 per cent. oxygen; and (5) when carbonized at 900° C. they yield upwards of 45 per cent. volatiles. The coke is of about 0·5 sp. gr. They lend themselves better to the process of "berginization" than the better known harder varieties of coals.

The more recent brown coals have an amorphous earthy character, while the older varieties exhibit either a laminated structure or a well-marked conchoidal fracture. Brown coals do not give such high yields of tar and oils as bituminous coals. Petrological investigation of brown coal is stated to have disproved the hypothesis that coal has its origin in lignin. It is alleged that Germany, by availing herself of natural supplies of brown coals for conversion into liquid fuel, will shortly be entirely independent of extraneous supplies of petrol.

The province of Alberta (Canada) is stated to have enough brown coal to supply the world with petrol for an indefinitely long period. (See also Coal, Lignite, and Peat.)

BROWNIAN MOVEMENT—See Colloid Chemistry and Emulsions.

BRUCINE—See Nux Vomica.

BRUCITE (MgO,H_2O)—A mineral of crystal system, No. 3, and sp. gr. 2·35. (See Magnesium.)

BRUNSWICK BLACK is prepared by melting together bitumen and boiled linseed oil in the proportions of 2 to 1, and adding two parts of turpentine to the mixture upon cooling.

BRUNSWICK GREEN—A trade name used in respect of several mixtures of Prussian blue and chrome yellow with or without other loadings, but more properly applied to copper oxychloride. (See Copper Compounds, p. 240.)

BRUSHITE—A natural hydrated calcium phosphate ($CaHPO_4,2H_2O$) found in the guano of Aves Island and Sombrero.

B.S.A.—See B.E.S.A.

B.Th.U.—British Thermal Units. (See Heat.)

"BUBBLER"—An apparatus for effecting efficient contact between gases and liquids in which the liquid flows over the surface of a perforated plate while the gas flows through the perforations.

BÜCHNER FUNNEL—See Filters.

BUFFER ACTION—See Volumetric Analyses.

BUNSEN BURNER—See Burners.

BURETTE—A graduated glass tube, open at the top and drawn out below, where it is fitted either with a glass stop-cock, or rubber tubing and a pinch-cock, for delivering measured quantities of liquids. A burette for micro-analysis of gas is described in abstract form in the *Analyst,* 1925, **50,** 153, and one for air-sensitive solutions in *Ind. Chem.,* 1931, vii., 216. (See Volumetric Analyses.)

BURGUNDY PITCH, of genuine character, is made by melting frankincense in water and straining it through cloth, but common rosin coloured with palm oil is said to be often substituted for it. It is a yellowish-brown, brittle, resinous substance, of aromatic odour, soluble in hot alcohol, and is used in medicine. (See Frankincense and Olibanum.)

BURNERS—Gas-burners are of various types, according to the application that is to be made of them, apart from those used for illumination.

Fish-Tail Burner—This resembles the old-fashioned sort used for lighting rooms, the flame of which is like a fish-tail or bat's wing in general form, and is chiefly used in connection with the bending of glass tubes (see Glass Tubes). The luminosity of the flame is due to the imperfect combustion of the gas, and consequent production of minute particles of the carbon constituent in an incandescent form.

Bunsen Burner—This consists of an iron or brass tube fixed to a foot-stand, and fitted with a mechanical arrangement below, whereby air can be admitted in regulated amount into admixture with the gas before burning. The gas issues from a small jet set inside at the base of the tube, and the air is admitted through several small holes in the surrounding tube also situate near its base, the amount of air being regulated by a movable disc of metal capable of closing these openings more or less as desired. In practice there is used about 1 part gas to 2½ parts of air. By this admixture the heat is intensified, perfect combustion of the carbon of the gas, as also of the hydrogen, being secured, thus producing a practically smokeless blue flame. Such burners are often provided with a movable ring which fits on to the top of the burner tube, so that the flame may, when desired, be broken up and made to assume a rose or ring form made up of a number of small blue flames, instead of the one long vertical column of flame. Both of these forms are employed for heating liquids contained in flasks or beakers, or for heating solid substances contained in crucibles, dishes, etc.; also for applying heat to sand-baths, water-baths, and water-ovens.

The flame of a Bunsen burner (like all ordinary flames) consists of two cones—the inner one, in which heated but imperfectly burned gases exist; and the outer one, where oxygen is in excess on the outside edge. Upon holding a bright copper wire across the flame so as to bisect the inner one, the wire will become coated with black copper oxide at the outer edges, while that part in the centre will remain bright. If now the blackened part be placed in the inner cone, the oxide will be reduced again to the metallic state, parting with its oxygen constituent to the gases in course of combustion. The outer area is con-

BURNERS (*Continued*)—
sequently called the *oxidizing flame*, and the inner cone the *reducing flame*.

When coal gas is burned in a current of air, water and carbon dioxide are among the products of its combustion. (See Flame and "Hammond" Burner.)

Blow-Pipe Burners—See Blow-Pipes.

Burners for sulphur-containing materials. (See article by W. H. Ibbotson (*Ind. Chem.*, 1928, iv., 515); Ores and Sulphur (Oxides), p. 874.)

BURNT ALUM—See Aluminium (Alums).

BURNT LIME—See Calcium (Lime).

BUTADIENE (or **ERYTHRENE**) (C_4H_6) can be prepared, among other methods, from normal butyl alcohol by first converting it into *n*-butyl chloride, chlorinating this in sunlight and then heating with soda-lime at 470° C. For further information concerning it and its employment in the product of so-called methyl-rubber, see *C.T.J.*, 1930, **86**, 182, on "New Butadiene Products"; Acetone and Rubber.

BUTANE—See Hydrocarbons.

BUTANOL (**BUTYL ALCOHOL**)—See Acetone and Alcohols (p. 24).

BUTEA GUM (**Bengal Kino**)—The hardened juice from incisions made in the stems of *Butea frondosa* (India and Burma). It is soluble in water when fresh, but rapidly oxidizes and becomes insoluble; used as a tanning material.

BUTTER—The fat of milk produced by churning, and consisting of about $\frac{4}{5}$ real fatty matter and $\frac{1}{5}$ butter-milk, which can be separated by melting, the fatty matter being composed of palmitin, myristin, stearin, olein, and small quantities of other glycerides. It possesses vitaminous qualities, and investigation has shown that there is no material loss of this "fat-soluble A," or growth vitamin property, during twelve months' storage at a temperature of −8° to −15° C. (See Vitamins.)

Butter varies in composition within certain limits, but on average it may be expressed as follows:

	Per Cent.
Fat	86·85
Curd	0·59
Salt	1·02
Water	11·54
	100·00

One published analysis of *dry* butter is as follows:

	Per Cent.
Palmitin, myristin, and other hard fats	53·98
Olein	37·82
Butyrin and other constituents	8·20
	100·00

Genuine Irish winter butter exhibits abnormal analytical results, as shown by P. S. Arup (*Analyst*, 1929, **54**, 634).

BUTTER (*Continued*)—

When hydrolysed, butter yields, according to one account, as follows: palmitic acid, 18·23 per cent.; myristic acid, 11·08 per cent.; lauric acid, 16·40 per cent.; stearic acid, 0·49 per cent.; oleic acid, 36·10 per cent.; caproic, caprylic, and capric acids, 3·23 per cent.; butyric acid, 6·13 per cent.; glycerine, 12·50 per cent.

According to C. Ainsworth Mitchell, the stearic acid content of butter fat ranges from nil up to 22 per cent. at least. (See *Analyst*, 1924, **49,** 515; also Hilditch and Jones, *Ibid.*, 1929, **54,** 75-96.)

The fatty acids of a butter examined by F. Frog and Schmidt-Nielsen have been given as follows: acetic acid, a trace; butyric acid, 3·4 per cent.; caproic acid, 3·3 per cent.; caprylic acid, 1·9 per cent.; capric acid, 3 per cent.; lauric acid, 3·7 per cent.; myristic acid, 12·9 per cent.; palmitic acid, 20·8 per cent.; stearic acid, 6·2 per cent.; oleic acid, 27·0 per cent.; unidentified acids, 9·8 per cent.; residue from distillation, 8 per cent.

Butter has a sp. gr. of 0·926 to 0·940; a sap. v. of from 220 to 233; an i.v. of from 26 to 38; and a ref. ind. of 1·4650 at 60° C.

The fat of goat's butter gives figures ranging as follows: Reichert-Wollny value 20·8 to 27·77, ref. ind. 1·4541 to 1·4559, i.v. 24·73 to 34·84, and sp. gr. at 100° F. from 0·9169 to 0·9346 (Knowles and Urquhart, *Analyst*, 1924, **49,** 509); detailed analytical figures of the composition of some New Zealand butters are given in the paper of Hilditch and Jones referred to above. Variations in composition of butter due to seasonal changes and varying feeding condition is subject of a paper by Hilditch and Sleightholme (*Biochem. J.*, 1930, **24,** 1098); and the glyceride structure of butter (*Analyst*, 1931, **56,** 541, same authors).

BUTYL—The univalent radical group $CH_3.CH_2.CH_2.CH_2$—

BUTYL ACETATE ($CH_3.COO.C_4H_9$) is made from butyl alcohol, and used largely as a solvent in making pyroxylin, lacquers, perfumes, etc.

BUTYL ALCOHOL—See Acetone and Alcohols, p. 24.

BUTYLAMINE—See Amines.

BUTYLENE—A hydrocarbon of the Olefine series. (See Hydrocarbons.)

BUTYRIC ACID ($C_4H_8O_2$ or $CH_3(CH_2)_2CO_2H$) is produced by the oxidation of the corresponding butyl alcohol and in the butyric fermentation of sugar or starch, being secondarily produced from lactic acid; it also occurs in glyceric combination in butter, and communicates the so-called rancid odour to that substance when stale. It is also produced by the "Ketol" process in France, calcium butyrate and cellulose butyrate being among the products, the last named being a possible substitute for cellulose acetate in making "Rayon." It is found present in the free state in perspiration and in the secretions of certain insects. It is a colourless liquid of rancid odour when volatilized, b.p. 162·4° C., sp. gr. 0·958 to 0·960; is used in medicine, varnish-making, and to some extent in tanning processes, etc. (See Acids and Ketol.)

BUTYROMETER—An instrument for determining the amount of butter in milk.

"CABTYRIT"—A British reinforcing material derived from rubber, said to withstand the action of hydrochloric acid, especially when concentrated and hot (up to 110° C.), also many other acids, but not recommended for nitric acid. It is used for lining tanks and can also be applied in paint or spray form to iron surfaces for protection against corrosion.

CACAO (COCOA) and CACAO BUTTER—The seeds of *Theobroma cacao* and other members of the genus *Sterculiaceæ* of Africa, South America, West Indies, and certain tropical parts of Asia (some twenty-five countries in all), yield the nutritive substance popularly known as cocoa. The beans, which differ in certain particulars, all contain much fatty matter, and about 1 per cent. of theobromine ($C_7H_8N_4O_2$), or from 2·2 to 3·9 per cent. calculated on the dry fat-free material, together with about 0·4 per cent. of caffeine. The theobromine content of the nib of the bean varies with the degree of fermentation to which the latter has been subjected, and also with the variety—Criollo (whitish bean) or Forastero (purple bean)—to which it belongs, the Forastero being the richer in content. The shells themselves contain approximately 0·2 per cent. of theobromine, passing thereinto during fermentation. The germ, as commercially separated from roasted cacao beans, contains about 2·1 per cent. theobromine. The aroma of cacao is due to the presence of about 0·006 per cent. of linalool. The fat ranges from 50 to 56 per cent., has the consistence of suet, and is a mixture of the glycerides of oleic, stearic, and palmitic acids, with some proportion of lauric acid ($C_{12}H_{24}O_2$). The theobromic acid ($C_{64}H_{128}O_2$), which appeared to be contained in a specimen investigated by Kingzett many years ago, is at any rate not a constant constituent. (*J.C.S. Trans.*, 1878, p. 38.) According to one account, the stearine content amounts to some 40 per cent., and the oleic acid to about 31 per cent., but a more recent analysis gives the proportions of acids as follows: oleic, 43 to 45 per cent.; palmitic, 23 to 25 per cent.; and stearic, 31 to 33 per cent. In any case, the composition appears to be of somewhat variable character. A general estimate of the distribution of glycerides in cacao butter, as determined by newer methods of investigation, is given by C. H. Lea. (See *J.S.C.I.*, 1929, **48,** 41 T.)

The non-volatile acid contained in cacao sweatings and cacao seed pulp is, according to F. Hardy (*J.S.C.I.*, 1925, **44,** 305 T), citric acid, the amount recoverable from some 1·32 kilogrammes of pulp being approximately 9·1 gramme, or 0·7 per cent., and he states that some 7 or 8 million gallons of the sweatings—the liquor that drains away from the seeds during fermentation—are run to waste annually.

Cacao shell is used to some extent as an ingredient in compounding cattle foods, also as a fuel, and as a manure after disintegration.

The fat resulting from the fermentation of cacao shell (up to 4 per cent. or more) after refining can be used for edible purposes, and is also suitable for soap-making.

Cacao butter is of sp. gr. 0·95 to 0·97, m.p. from 32° to 34° C., i.v. of from 34 to 38, sap. v. of 192 to 198, and a refraction of 45·6 to 46·5 (butyro-refractometer at 40° C.). It is used in making cosmetics,

CACAO and CACAO BUTTER (*Continued*)—in pharmacy, and in chocolate-making, and is quite distinct from cocoanut oil, which is yielded by the cocoa palm (*Cocus nucifera*).

Chocolate is a preparation of roasted cacao beans with flour or other farinaceous matter and sugar; whereas cacao is the powder made from the roasted beans. (See *Cocoa and Chocolate: their Chemistry and Manufacture*, by R. Whymper (J. and A. Churchill, London); *Cocoa and Chocolate Manufacture*, by H. W. Bywaters (J. and A. Churchill); *Cocoa: World Production and Trade* (H.M. Stationery Office); Chocolate, Cocoa, and Theobromine.)

CACODYL—A methyl arsenide ($As_2(CH_3)_4$) prepared by heating a mixture of arsenious oxide and potassium acetate. It is a colourless liquid, insoluble in water, of offensive garlic-like odour, b.p. 170° C., extremely poisonous, and readily inflammable in air. It combines with chlorine, and acts as an organo-metallic radical, forming, for example, cacodylic acid ($As(CH_3)_2HO_2$.), a colourless, odourless, poisonous, crystalline body, soluble in water and alcohol.

CADAVERINE—See Albumins and Ptomaines.

CADE OIL (Juniper Tar Oil)—Obtained by the dry distillation of the wood of the *Juniperus oxycedrus* (Mediterranean countries). A thick, clear liquid of burning, bitter taste, sp. gr. of from 0·98 to 1·06 at 15° C.; soluble in alcohol and ether; used in perfumery, medicine, and for making animal soap, etc. It contains guaiacol and cadinene.

CADINENE ($C_{15}H_{24}$)—A lævorotatory, dicyclic sesquiterpene, occurring in cade, betel, camphor, juniper, patchouli, and olibanum oils. It is a viscous liquid of sp. gr. about 0·92, b.p. 274° C., and forms beautiful additive compounds with the halogen acids. (See Henderson and Roberts (*J.C.S.*, 1926, p. 2811).)

CADMIUM (Cd) **and its Compounds**—Atomic weight, 112·4; sp. gr., 8·65; m.p., 321° C., having, it is stated, six isotopes. It is found naturally in the form of sulphide (CdS) in a rare mineral named *Greenockite* (crystal system, No. 3, and sp. gr. 4·8), and in a number of zinc ores, both as sulphide and carbonate, but not in the metallic state. It is produced in the process of extracting zinc from its ores, being found in the first fractions coming over when distilling them, partly in the metallic condition and partly as oxide, the proportion being about 1 part cadmium to 200 parts zinc. It can also be recovered from the "bag-house" condensation products from lead and copper furnaces by an electrolytic process. Australia, Canada, and the U.S.A. contribute in particular to the world's supply of cadmium, which in 1929 was 2,000 tons.

An interesting property of this metal is its power of lowering the melting-point of certain alloys when incorporated in small proportion, thus making it useful in the manufacture of fusible plugs in sprinkler systems for fire prevention. One alloy in particular, composed of 90·8 parts lead, 7·8 parts cadmium, and 1·4 parts zinc, is an excellent one for general soldering purposes involving the use of the iron. Cadmium also gives valuable protection to iron and steel against atmo-

CADMIUM (*Continued*)—
spheric corrosion when electrolytically deposited thereon as a coating, and is not so readily corroded as zinc, hence the occasional practice of adding about 5 per cent. of cadmium powder to the zinc dust used in "sherardizing" (see Metals, p. 577). (See S. Wernick, *Ind. Chem.*, 1928, iv., 234.)

The metal is of a bluish-white colour, and its compounds include the oxide (CdO), which is formed when the metal is burned in the air; the hydroxide $Cd(OH)_2$, a white compound insoluble in water but soluble in acids and ammonium hydroxide; the chloride ($CdCl_2$), a soluble salt used in photography, dyeing, plating practice (in place of zinc), and calico-printing; the bromide ($CdBr_2$), a yellow, soluble, crystalline salt used in photography; the sulphide (CdS), a yellow compound insoluble in water, used as a pigment in oil and water-colour painting; the nitrate ($Cd(NO_3)_2.4H_2O$), a white salt soluble in water, used for colouring glass and porcelain; and cadmium tungstate ($CdWoO_4$), a yellow crystalline salt, soluble in alcohol, and used in making fluorescent paint.

Cadmium oleate exhibits greater resistance to hydrolysis than zinc oleate and promises to have a superior industrial future than the zinc compound as an impregnating material. Trials have shown it to be very effective in waterproofing textiles and for impregnating porous ceramic articles, tiles, etc. (See *Chem. Zeit.*, November 29, 1929.)

Cadmium sulphide as precipitated from a soluble salt is gelatinous and intractable for filtration and other treatment. (See *C.T.J.*, 1925, **77,** 119, and 1927, **80,** 59.) The possibilities of electrolytic production of "Cadmium Yellow" directly from stick cadmium is the subject of an article by Fink and Grosvenor (see *C.T.J.*, 1930, **87,** 323).

Cadmium selenide is used to some extent as a satisfactory rubber pigment which stands well in vulcanization.

Red cadmium pigments ranging from orange to purplish-red are made by mixing cadmium sulphide with cadmium selenide and barium sulphate.

Pale cadmium colours are produced industrially by adding ammonium monosulphide to cadmium oxalate, observing certain conditions of dilution and temperature, and dark colours from sodium monosulphide and cadmium carbonate, the nitrate being used as the source of the other cadmium compounds.

Cadmium plating and its value as a rust preventive is the subject of articles by S. Wernick (*Ind. Chem.*, 1928, iv., 234; Metallurgical Supplement of *Engineer,* March 29, 1929; and *Ind. Chem.*, 1931, vii., 358); for further details respecting the production of cadmium and the uses of the metal and its compounds, see N. F. Budgen (*C.T.J.*, 1924, **75,** 641; *Ibid.*, 1928, **83,** 122; 1929, **84,** 463; and 1930, **87,** 618; also *Ind. Chem.,* 1925, i., 293).

"CADMOPONES" (Cadmium Lithopones)—See Paints.

CÆSIUM (Cs) **and its Compounds**—Atomic weight, 132·8 and alleged isotope of number 133; sp. gr., 1·87; m.p., 26° to 28° C.; b.p. 670° C. It is a rare element belonging to the group of alkali metals, found in

CÆSIUM (*Continued*)—

association with potassium and sodium in some alkali minerals (including *porphyrites, lepidolites,* and *carnallite*), also in certain mineral waters, but the most prolific source is the mineral *pollux,* or *pollucite,* in which it is contained in the form of a compound silicate of aluminium and cæsium, yielding from 31 to 37 per cent. of the oxide Cs_2O.

It is a silver-white, soft, ductile metal, which readily tarnishes by oxidation in the air and therefore has to be kept in naphtha. It is used in making thermionic valves. Its compounds are very like those of potassium; they include the carbonate (Cs_2CO_3), which is white, soluble, and used in the mineral-water trade; the chloride (CsCl), a colourless, soluble, crystalline salt similarly used, and in medicine; the nitrate ($CsNO_3$), a white crystalline salt soluble in water; the oxides, Cs_2O, Cs_2O_2, Cs_2O_3, and Cs_2O_4, all of which are yellow or red, excepting the Cs_2O_3, which is chocolate brown, the silicate (Cs_2SiO_3), insoluble, and used in ceramics; and the sulphate (Cs_2SO_4), a colourless crystalline salt soluble in water, used in brewing and making mineral waters.

CAFFEINE (**Theine**) ($C_8H_{10}N_4O_2,H_2O$), a purine base (tri-methyl-xanthine), being the active principle of coffee (which contains varying proportions up to about 2 per cent.), kola nuts, tea (which contains from 2·5 to nearly 5 per cent.), and the *Yocca* plant. It melts at 230·5° C., sublimes at 237° C., and crystallizes from water in white silky needles, having a slightly bitter taste. It acts as a stimulant of the physical centres of the brain; is soluble in chloroform, not very soluble in cold water, but much more so in boiling water, and together with some of its salts is used in medicine. It can be prepared from xanthine. A basic body named caffeidine results when caffeine is shaken up with sodium hydroxide solution (see Biltz and Rakett, *B.C.A.*, 1928, A, 906; Coffee and Tea).

CAJUPUT (CASEPUT), OIL OF—An essential oil used in medicine, obtained in India and the Molucca Islands, by distillation with water of the leaves of the *Melaleuca leucodendron* (N.O. Myrtaceæ). It is of green colour and camphoraceous odour, soluble in alcohol and ether, contains cineol—at times up to 58 per cent. or more—terpineol, etc. Sp. gr., 0·92 to 0·93 at 15° C.; opt. rot., $-0°$ to $-4°$; ref. ind., 1·460 to 1·470 at 25 C°.

CALABAR BEAN (**Ordeal Bean**)—The seed or bean of *Physostigma venenosum* (N.O. Leguminosæ) of West Africa, containing an alkaloid named *eserine* or *physostigmine,* a solution of which has an action on the pupil of the eye the opposite to that which belladonna exercises—that is, contraction instead of dilatation. Eserine ($C_{15}H_{21}N_3O_2$) is soluble in alcohol and ether. Physostigmine (eserine) sulphate is prepared from the seed and used in medicine. (See Polonovski and Cappelaere (*Analyst,* 1931, **56,** 818) and Physostigmine.)

CALAMINE (**Smithsonite**)—Mineral zinc carbonate ($ZnCO_3$), of crystal system, No. 3, and sp. gr. 4 to 4·5. (See Zinc.)

CALAMUS OIL (**Oil of Sweet Flag**)—Distilled from the rhizome of *Acorus calamus,* and used in perfumery, etc. It is a thick, yellowish, aromatic

CALAMUS OIL (*Continued*)—oil, soluble in alcohol and ether, of sp. gr. about 0·96, and ref. ind. about 1·5; yield is 2·8 per cent.

CALCAREOUS SPAR—Native crystallized calcium carbonate.

CALCINATION—Burning (calcining) or incinerating operation employed for the conversion of chalk into lime by burning; the reduction of sulphur content of certain iron ores; the dehydration of fuller's earth and bauxite; the preparation of barium sulphide and lithopone; the revivification of bone black; the calcination of lime sludge, bones, etc.

When conducted in the air it is a process of oxidation largely resorted to, as a stage in the separation of metals from their ores.

Such operations are carried out in the laboratory for the most part in crucibles, and in manufacturing operations in rotary kilns and reverberatory furnaces. (See C. H. Butcher (*Ind. Chem.*, 1929, v., 25); Calx, Kilns, Ores, and Oxidation.)

CALCITE ($CaCO_3$)—See Calcium.

CALCIUM (Ca) **and its Compounds**—Atomic weight, 40·09; sp. gr., 1·55; m.p., 851 ± 1° (A. von Antropoff and E. Falk, *B.C.A.*, 1930, A, 699); b.p., 1,712 ± 5° (Hartmann and Schneider, *B.C.A.*, 1929, A, 754); credited with two isotopes. Calcium is not met with in nature in the metallic state, but chiefly in the form of carbonate ($CaCO_3$), in minerals such as *limestone, chalk, Iceland spar, marble,* and *coral,* in which and other forms it constitutes a considerable part of the earth's crust. In the form of *arragonite* it occurs naturally in orthorhombic crystals, and in *calcspar* (calcite) as hexagonal crystals (crystal system, No. 3, and sp. gr. 2·6 to 2·7), in both of which forms it can be prepared in the laboratory.

In an anhydrous state the sulphate exists as the mineral *anhydrite* ($CaSO_4$), and in other forms it exists as *selenite, alabaster,* and *gypsum* ($CaSO_4,2H_2O$). Calcium is also found in nature in combination with fluorine as *fluorspar* (CaF_2), and in combination with phosphoric acid and calcium fluoride, in the mineral known as *apatite*. (See Apatite.)

Calcium is a soft and whitish metal obtained in the metallic state by the electrolysis of fused calcium chloride using a carbon anode, and in crystalline form by condensation of its vapour. It is a good hydrogenation catalyst, and when heated in oxygen to 300° C. it inflames, and the lime thus produced is fused by the heat.

Lime (calcium oxide, or so-called burnt lime, CaO) is made on a very large scale by burning limestone (chalk) with coal in kilns lined with basic bricks containing 50 per cent. silica, when the carbonate parts with carbon dioxide and leaves lime (quicklime) behind; or the limestone is baked alone in furnaces at a heat sufficiently great to break it up into quicklime and carbon dioxide gas ($CaCO_3 = CaO + CO_2$), "producer gas" being used for generating the heat. (See *C.T.J.*, 1927, **80,** 420 and 531; M. F. Goudge on "Limestone and its Products" (*C.T.J.*, 1931, **88,** 530); A. Grounds (*Ind. Chem.*, 1927, iii., 349); W. Woodhouse (*Chem. and Ind.*, 1932, **51,** 115).)

Rotary kilns present certain advantages over shaft kilns, and a

CALCIUM (*Continued*)—

minimum temperature of 900° C. is required, the regulation of the air supply being the most important factor in determining the efficiency and fuel economy. It is estimated that 4 tons of lime should be obtained per ton of fuel burned, with a thermal efficiency of over 60 per cent. (V. J. Azbe, *B.C.A.*, 1926, B, 154); see also C. H. Butcher (*Ind. Chem.*, 1929, v., 25, in which article he deals with flue gases, waste heat in drying, and calcining practice).

When produced at 1,200° lime is "overburned," and does not slake so readily as that resulting from production at 1,100°, and when burned at 1,700°, it is much overburned, and slakes very slowly. The qualities of slaked lime from reburned sludges are the subject of an article in the *C.T.J.*, 1925, **76,** 726.

It may be noted that there is a patented process (Reid's) for utilizing the waste gases produced in lime-burning for generating electricity.

Quicklime (CaO) is a white and nearly infusible substance which, when mixed with water, forms the white powder known as calcium hydroxide, or slaked lime, $Ca(HO)_2$, which in the pure state is said to have a density of 2·239. Slaking with excess water produces a product much finer than that which results from use of the theoretical quantity of steam (see *C.T.J.*, 1928, **83,** 327). During slaking with a minimum of water the heat evolved rises above 270° C., a temperature at which untreated and dry woods will commence to burn.

"Hydralime" is a brand described as a practically pure hydroxide, while another grey variety contains proportions of silica and alumina, said to endow the material with special setting property and strength.

Lime is used very largely in the making of glass, mortar, putty, and cement; as an accelerator in the rubber industry; the preparation of limewash, distemper paints, and as the base in the manufacture of bleaching-powder; also as a dressing for skins to remove grease and fur, and for application to clayey soils to make the land more friable. Lime constitutes an important plant factor, capable as it is of acting chemically, physically, and bacteriologically in the soil; it can also be employed as a fungicide, insecticide, and water softener. (See O. Bowles on "The Lime Industry" (*C.T.J.*, 1927, **80,** 505; W. J. Rees on "Modern Progress in Kiln Design" (*C.T.J.*, 1931, **88,** 273); Cowper and Williams on "Building Limes: Putty Density and Volume Yield," (*J.S.C.I.*, 1929, **84,** 276 T); Jackman and Howell on "Calcium Compounds in Laundered Fabrics" (*Chem. and Ind.*, 1930, **49,** 787); and "A Modern Lime Hydrating Plant" (*Ind. Chem.*, 1932, viii., 99).)

Lime-Water is a solution of calcium hydroxide ($Ca(HO)_2$), which is soluble in water to the extent of 0·14 part in 100 parts at the ordinary temperature, or about 121·7 grains per gallon.

Calcium Carbonate ($CaCO_3$) occurs in nature in a great variety of forms, both anhydrous and hydrated, the latter as *hydrocalcite* ($CaCO_35H_2O$) and as $CaCO_3,3H_2O$. A hexahydrate ($CaCO_36H_2O$) is also known. Calcium carbonate is almost insoluble in water, but dissolves readily when the water contains carbon dioxide, and the so-called

CALCIUM (*Continued*)—

temporary hardness of water is due to the amount thus held in solution, but which is deposited when the water is boiled owing to the consequent expulsion of that gas. The *permanent hardness* of water is due to the calcium sulphate and other mineral salts which are held otherwise in solution.

Calcium carbonate is a by-product in several chemical manufactures, and in this connection it is of use in cement-making.

Chalk, the native carbonate of an earthy nature, is used as a dressing for heavy lands and making cement, etc. Precipitated chalk is a well-known form of calcium carbonate, used in the preparation of dentifrices, putty, and pigments, in the glass and paper manufactures, and as a material for stone-dusting of mines. (See also Oolite.)

Calcium Silicide—A ferrous metal deoxidizer. (See *C.T.J.*, 1927, **80**, 257.)

Calcium Sulphate, which is practically insoluble in water, occurs in nature and exists in another form, artificially prepared, as monohydrate ($CaSO_4H_2O$), of sp. gr. 2·32. From a given pair of precipitants it can also be precipitated either as the dihydrate or the hemihydrate (Smits, *J.C.S.*, 1926, p. 2655).

For technological purposes the gypsum rock, or "gypsite" (an earthy disintegrated rock), is now dried in a rotating cylinder, followed by grinding in special mills, screening, calcination, and regrinding.

Gypsum ($CaSO_4$) of sp. gr. 2·964 exhibits great capability to resist fire, and finds considerable employment as a protective material in building construction; also in the paint trade; as a filling material in paper-making; in the cotton and lace trades to give a finish to certain classes of goods; and as a retarder in the setting of Portland cement; whereas anhydrite is a poor retarder.

Its employment in the manufacture of sulphuric acid and ammonium sulphate respectively is referred to elsewhere.

Anhydrite ($CaSO_4$) occurs in large quantities in the Hartz Mountains, Upper Italy, some of the U.S.A., and elsewhere, and is often found in association with gypsum. It is of crystal system, No. 4, cannot be hydrated by heating with water under pressure, but after grinding to colloid form, hydration slowly occurs by keeping wet for some weeks. According, however, to A. E. Flynn, plasters and cements can be made from it more cheaply than from gypsum, etc., if certain salts which act as catalysers are used in hydration of the anhydrite (see *Chem. and Ind.*, 1930, **49**, 685).

The sulphate mineral raised in Great Britain in 1930 was 843,000 tons.

Plaster of Paris, $(CaSO_4)_2,H_2O$, is calcium sulphate which has been deprived of part of its water of combination by heat. It has a great affinity for recombining with more water, with which it sets into a hard mass, and is largely used for lining walls, moulding, and other purposes. The sulphate ($CaSO_42H_2O$) (sp. gr. 2·3) exists in two crystalline forms—viz., the monosymmetric (No. 6) and orthorhombic (No. 5) or labile form—and during heating a period of induction occurs in which the

CALCIUM (*Continued*)—

change from the first named to that of the other takes place without loss of water. Upon heating it from 109° to 130° C. it loses three-fourths of its water and forms the hemihydrate ($CaSO_4,\frac{1}{2}H_2O$), and it is to the reconversion of this, by combination with more water, into the form of the dihydrate that plaster of Paris, which is largely made from it, owes its setting powers. This setting is accompanied by a contraction, followed by an expansion due to a change in the crystal system from the monosymmetric system of gypsum into the rhombic type of the dihydrate. As ordinarily prepared from gypsum by grinding and calcination by indirect heating there are some small particles of gypsum which have not lost water, and they act as nuclei for the production of new crystals, thus producing feathery arms, or so-called "spheralites," which interlock, and this, with cohesion between the crystals, provides the setting. (See paper since published by Gibson and Johnson (*J.S.C.I.*, 1932, **51**, 25 T).)

It is said to lose $>$99 per cent. water when heated at 115° C. for twenty-two hours. (See A. L. Parsons, *B.C.A.*, 1928, A, 852.) The temperatures required to convert gypsum into $CaSO_4,\frac{1}{2}H_2O$ and that substance into $CaSO_4$ depend upon several circumstances, the first so-called "boil" covering the first stage, varying from 108° to 130° C., and the second "boil," completing the dehydration, varying from 160° to 200° C., the product being known as "anhydrite." (See Laschtschenko and Kompanski on "The Relationship between the Different Forms of Calcium Sulphate at High Temperatures" (*B.C.A.*, 1928, A, 955).)

Calcium sulphate in its various forms is used in the ceramic, paint, and paper industries; also in making statues, busts, "stucco," polishing powders, etc. Bad plaster-work has been attributed to use of an excess of water for setting. Waste lime and calcium sulphate are utilized to some extent in the manufacture of tiles and the preparation of the composition $2CaSO_4,\frac{1}{2}H_2O$. (See J. B. C. Kershaw, *Ind. Chem.*, 1926, ii., 486, and *C.T.J.*, 1927, **81**, 63.)

"Stucco" is a coloured form of plaster prepared with a solution of size and used as a wall covering, etc.

The "drying of gypsum" for making "stucco," model and floor gypsum, etc., and the utilization of calcium sulphate waste is dealt with in the *C.T.J.*, 1925, **77**, 155, and *Ind. Chem.*, 1926, ii., 343.

Calcium Carbide (CaC_2) (sp. gr. 2·22)—When ground lime or chalk is strongly heated with coke in an electric furnace at about 3,000° C., calcium carbide (CaC_2) is produced, and this product is now made on a large scale for use in the preparation of calcium cyanamide and acetylene gas (for lighting and other purposes). In practice, 1 ton of calcined limestone mixed with 14 cwts. of anthracite is used to produce 1 ton of carbide.

The density of the product varies according to the character of furnace used, that from a single-phase furnace having a different texture from that made in a three-phase furnace.

CALCIUM (*Continued*)—

The by-product of its decomposition with water is slaked lime, and this can be utilized in the building trade as a sand lime in mortar making or clinker brick, also as a soil dressing and for causticizing the soda-liquors of paper mills.

Calcium carbide is also produced as a by-product in the manufacture of phosphorus. (See Phosphorus.)

Some details concerning its production are given (*C.T.J.*, 1925, **76,** 723, and 1927, **80,** 391. (See also review of book on the calcium carbide industry, *Ibid.*, 1930, **87,** 618; Acetylene and Carbides.)

Calcium Sulphide (CaS) exhibits the property of giving out a phosphorescent light in the dark, and is used in the preparation of luminous paint. It is but slightly soluble in water, and when boiled in water it is decomposed, forming the hydroxide $Ca(HO)_2$ and the hydrosulphide ($Ca(HS)_2$)—a product which is used for unhairing skins before tanning them.

Calcium Chloride ($CaCl_2$) was a by-product in the old method of making potassium chlorate, but is now made from the still liquors of the ammonia-soda process. It can be obtained in a crystalline form combined with water ($CaCl_26H_2O$), which melts at 29° C. in its own water, and when heated above 200° C. the whole of the water is dissipated and the anhydrous compound results. This is very hygroscopic, extremely soluble in water, and is employed for drying coal gas and other gases by passing them over or through vessels packed with it.

In one commercial form it is prepared as a solid containing from 70 to 75 per cent., and is used in ice-making, for refrigeration, and in the concrete, cotton, and other trades. (See Concrete.)

Calcium Nitrate ($Ca(NO_3)_2.4H_2O$) is a white deliquescent substance, soluble in water, and used in pyrotechnics.

Calcium Phosphate (tricalcium phosphate, $Ca_3(PO_4)_2$) is the most important of the phosphates of calcium, and occurs in the mineral forms of *sombrerite, coprolites,* and *osteolite* ($Ca_3(PO_4)_2.2H_2O$). When acted upon by sulphuric acid it is decomposed, forming a mixture of another phosphate and calcium sulphate known commercially as superphosphate of lime, which is marketed of various strengths. The electrolytic production of dicalcium phosphate from Indian apatite and the value of the product as a fertilizer form the subject of a paper by Surendraral Das (*J.S.C.I.*, 1930, **49,** 490 T). (See Superphosphate of Lime.)

Calcium phosphate is used in ceramics, enamelling, polishing, and making "milk glass."

Calcium Biphosphate, or acid calcium phosphate ($CaH_4(PO_4)_2.2H_2O$), is a colourless deliquescent crystalline salt soluble in water, made by reaction between rock phosphate and sulphuric acid. It is used as a baking powder for making "self-raising flour" in place of cream of tartar, also as a constituent of general baking and egg powders.

Calcium Fluoride (CaF_2) is found as *fluorspar* in crystalline cubes in Derbyshire and Cumberland, and is used as a flux in the reduction of metals, also in the preparation of enamels. When heated with strong

CALCIUM (*Continued*)—

sulphuric acid, hydrofluoric acid and calcium sulphate are produced. (See Fluorine.)

Bleaching-powder (so-called "chloride of lime") is manufactured on a large scale by the action of chlorine gas upon moist slaked lime (free from iron and magnesium) at not exceeding 40° C. and until the product contains about from 35 to 38 per cent. of chlorine, the interaction that takes place being represented by the equation $Ca(HO)_2 + Cl_2 = CaOCl_2 + H_2O$, although there is always an excess of lime left in the resulting product. Confirming some previous results obtained by H. Ditz (A, 1901, 239), Neumann and Haebler state that the chlorination of calcium hydroxide at 35° to 40° C. yields the hydrates $3CaOCl_2,CaO,4H_2O$ and $3CaOCl_2,CaO,6H_2O$, the latter corresponding to ordinary bleaching-powder; while chlorination at 15° C. gives a hydrate $CaOCl_2,CaO,H_2O$, one molecule of water being firmly held in all these compounds (*B.C.A.*, 1930, A, 176); see also S. Urano, *B.C.A.*, 1931, B, 880.

A new special Italian make of bleaching-powder in both the hydrated and anhydrous crystalline forms is prepared by the action of chlorine gas at 40° C. upon finely divided hydrated lime suspended in carbon tetrachloride and named "Siclor." (See Carughi and Paoloni, *B.C.A.*, 1930, B, 417, and *C.T.J.*, 1930, **86**, 225 and 252).

The manufacture is generally conducted in chambers of various designs in which the lime is exposed on the floor or shelves in layers of varying thickness from a few centimetres upwards, but there are other installations in which rotary action is employed to carry the lime through a tube or over a plane in which it is exposed to the action of the chlorine, and thus made to present fresh surfaces as it moves along.

In the "Backmann" system the lime is mechanically moved down from a hopper on to a successive number of stages contained in a chamber, in which it encounters the current of chlorine gas. This method is reported to produce a satisfactory product even when the supply of gas is discontinuous or irregular, the temperature being regulated between 35° and 40° C. as maximum and gradually reduced as the chlorine content increases. (See *C.T.J.*, 1925, **76**, 133, and 1928, **83**, 361.) An illustration of bleaching-powder chambers is given (*Ind. Chem.*, 1930, vi., 486).

Above 45° C. there is danger of formation of chlorate, and at 50° C. bleaching-powder begins to rapidly decompose. The available chlorine content suffers loss by storage fairly regularly, the total loss being for the most part as chloride.

A high test product containing 40 to 48 per cent. of available chlorine is obtained by adding pure slaked lime to a clear solution of bleaching-powder (5 to 6 per cent. available chlorine) and evaporation *in vacuo* at 40° C. This basic hypochlorite is represented as $Ca(OCl)_2,2Ca(OH)_2$, and is obtainable in crystalline form.

Bleaching-powder yields, by treatment with water, the normal hypochlorite, and from the solution, the crystallized hypochlorite can be obtained of 90 to 95 per cent. available chlorine by Kingzett's process of

CALCIUM (*Continued*)—

evaporation *in vacuo*. (See *J.C.S.*, 1875, p. 456; *Ibid.*, 1928, p. 528; and *Chem. News*, July 16, 1875; and S. Urano, *B.C.A.*, 1926, B, 485.)

Bleaching-powder occasionally explodes, due to contamination with iron and manganese, and solutions of it are decomposed by small amounts of other catalytic agents such as cobalt and nickel.

According to some Japanese chemists, an 80 per cent. available chlorine material can be produced by using a milk of lime free from carbonate, the exclusion of carbon dioxide, and drying the resulting paste; while an American "high-test" calcium hypochlorite containing 60 to 65 per cent. available chlorine has recently been placed on the market.

Pure calcium hypochlorite with 70 per cent. available chlorine is stated to evolve oxygen slowly below 100° C. and explodes violently with liberation of its oxygen content at 112° C. (Weichherz, *B.C.A.*, 1928, B, 783).

Bleaching-powder is largely employed in the arts, goods to be bleached being first of all dipped into a dilute solution of the substance and then passed through a dilute acid solution, chlorine gas being thus liberated within the fibres of the fabrics. Apart from its use in the paper and textile trades for bleaching, it is used also on a considerable scale as a sanitary reagent and for refining petroleum oil.

Bleaching by chlorine is really a process of oxidation, as the chlorine decomposes water in the act, liberating nascent oxygen; thus indigo blue is converted by chlorine into an orange-red non-tinctorial principle named isatin.

Calcium Cyanide—There is an American process for making this compound from powdered calcium carbide and liquid hydrocyanic acid in a vacuum crystallizer. (See *C.T.J.*, 1926, **78**, 255, and F. J. Metzer, *B.C.A.*, 1926, B, 272; also Hydrocyanic Acid.)

Calcium Cyanamide or **Nitro-lime** ($CaCN_2$)—See Cyanamide.

Calcium Acetate ($Ca(C_2H_3O_2)_2H_2O$) is a white crystalline body, soluble in water, employed in the manufacture of acetone, acetic acid, dyeing, and calico printing. It is marketed also as "Lime Acetate," brown and grey (80 per cent.).

Calcium Lactate ($Ca(C_3H_5O_3)_2,5H_2O$) is colourless, soluble in water, and used in medicine.

Calcium Arsenate ($Ca_3(AsO_4)_2$), made from calcium chloride and sodium arsenate, is a white poisonous powder, slightly soluble in water, extensively used for eradicating the boll-weevil from growing cotton plants by dusting them at night, 5 to 7 lbs. being used per acre, and otherwise as an insecticide and fungicide.

There is an electrolytic process for making this product more economically, in which white arsenic (As_2O_3) is dissolved in caustic soda and the sodium arsenite solution thus produced is converted into sodium arsenate by electrolytic treatment, after which, by treatment with hydrated lime in water, calcium arsenate is produced. The details of the process will be found in a paper by S. J. Lloyd and A. M. Kennedy (*C.T.J.*, 1925, **77**, 120), and it is alleged that calcium arsenate as thus

CALCIUM (*Continued*)—

made, acts better than that otherwise made, for dusting on cotton plants, by reason of its greater adhering character.

It is stated that the toxicity of calcium arsenates decreases with increase in the molecular ratio $CaO : As_2O_3$ in combination, and that the acid arsenates are much more toxic than the basic ones.

Calcium Bisulphite ($Ca(HSO_3)_2$) is soluble in water, and is prepared in the form of a yellowish liquid, having a strong odour of sulphur dioxide, by the action of that gas on calcium hydroxide, the product being generally sold of sp. gr. 1·070 or 9° B. strength under the name of lime bisulphite. It is largely used in the manufacture of wood pulp, also as an antichlor, as a preservative, and for bleaching sponges.

Calcium Borate—See Pandermite.

Calcium Citrate ($Ca_3(C_6H_5O_7)_2 4H_2O$)—This salt is soluble in cold water, but nearly insoluble in hot water. (See Citric Acid.)

Calcium Caseinate—A preparation used for increasing the wetting and penetrating power of horticultural washes, thereby improving their insecticidal and fungicidal efficiency, as in the control of *Woolly Aphis.* Experience has shown that a 0·2 per cent. solution appears to be the lowest strength required to reduce the surface tension to a minimum, and give maximum spreading and wetting effect. (See Insecticides.)

Calcium Chlorate ($Ca(ClO_3)_2 2H_2O$) is a nearly white crystalline compound prepared by action of chlorine upon calcium hydroxide (milk of lime); soluble in water and used in making pyrotechnics and as a constituent of the weed-killing compound named "Weedex."

Calcium Permanganate ($Ca(MnO_4)_2.4H_2O$)—A violet crystalline salt, used for sterilizing, disinfecting, and in the textile trade.

Calcium Phosphide (Ca_2P_2)—A grey substance obtained by heating calcium phosphate and aluminium. It is decomposed by water, thus generating hydrogen phosphide, which takes fire in air. (See Phosphorus.)

Calcium Tungstate ($CaWO_4$)—A crystalline substance, insoluble in water, used in radiography and making luminous paint. (See Tungsten.)

Calcium Molybdate ($CaMoO_4$)—A white crystalline powder insoluble in water, but soluble in acids, made by fusing molybdenum ores with lime; used for making molybdic acid and as a substitute for ferromolybdenum in the manufacture of steel. According to H. C. Mabbe, it can be easily made for use in steel manufacture by roasting molybdenite at 600° C. until free from sulphur and then heating the resulting trioxide at 600° C. with finely powdered calcium carbonate (*B.C.A.*, 1930, B, 1149).

There are commercial preparations of calcium sulphite (in powder and tablets) and calcium ferrocyanide; while calcium silicate is now prepared in the form of grey pressed bricks.

"Lime-sulphur" (made from lime, sulphur, and water) is used as an insecticide and fungicide.

CALCULI (Urinary)—Concretions in the bladder consisting of or containing uric acid, ammonium and other urates, calcium oxalate, calcium

CALCULI (*Continued*)—
phosphate, the double phosphate of ammonium and magnesium, xanthine and cystine, generally constructed round a nucleus of some foreign substance, such as blood-corpuscles, etc.

"CALEDON" DYES—A new series of soluble character, including the "Solway," "Caledon," "Celatene," and "Soledon." (See *Ind. Chem.*, 1928, iv., 97, and Dyes.)

CALENDULA—See Marigold.

CALIBRATION—Calculating the calibre—*i.e.*, the diameter of the bore—of tubes, etc., before graduating. (See A. More on "Meniscus Corrections in Calibrations of Graduated Tubes" (*Analyst*, 1929, **54,** 630).)

CALICHE (Chile Nitre)—This impure "soda nitre" (sodium nitrate) occurs in almost unlimited quantities in South America, and more particularly in the district of Atacama in Peru, the average content of sodium nitrate being about 25 per cent.

New South African deposits containing on an average about 16 per cent. sodium nitrate have been found in the Gibeon district some fifty miles to the east of Mariental on the railway towards the Kalahari Desert.

According to one view, the origin of caliche is to be attributed to the transformation of the large quantities of ammonium chloride which impregnate the ash of Chilian volcanoes, the bacterial nitrification being intensified by radio-activity.

It is cheaper than potassium nitrate, and yields 9 per cent. more nitric acid when employed for the manufacture of sulphuric acid.

The following analyses have been published:

	No. 1, White Caliche.	No. 2, Brown Caliche.
	Per Cent.	Per Cent.
Sodium nitrate	70·62	60·97
,, iodate	1·90	0·73
,, chloride	22·39	16·85
,, sulphate	1·80	4·56
Calcium sulphate	0·87	1·31
Magnesium sulphate	0·51	5·88
Insoluble matter	0·92	4·06
Water	0·99	5·64
	100·00	100·00

It is often found covered by deposits of *costra,* which is a harder saline deposit of less value, and the table below gives analyses which have been published of it, and the "soda nitre" found beneath it in the basin of the Loa (Chile).

Sometimes, "soda nitre" is found in an almost pure state, and it can be made to contain from 95 to 96 per cent. by crushing, dissolving in water and recrystallizing, but it is stated that deposits containing as little as 10 per cent. can now be worked profitably. Apart from what is used in the chemical trades there is a much larger consumption as a fertilizing agent. (See Fertilizers.)

CALICHE (*Continued*)—

	"Soda Nitre."		"Costra."
	(1)	(2)	
Sodium nitrate	51·50	49·05	18·60
,, sulphate	8·09	9·02	16·64
,, chloride	22·08	28·95	33·80
Potassium chloride	8·55	4·57	2·44
Magnesium ,, ...	0·43	1·25	1·62
Calcium carbonate	0·12	0·15	0·09
Silica and iron oxide ..	0·90	2·80	3·00
Sodium iodide	Traces	Traces	—
Insoluble matter	6·00	3·18	20·10

It is reported that average Chilian caliche contains 0·15 per cent. iodine in the form of sodium iodate, and the method of its extraction is given by J. B. Faust. (See *B.C.A.*, 1926, B, 821.)

CALICO PRINTING—The art of imprinting colours on cotton cloth or calico with dyes, the spreading being prevented by the use of thickening agents, such as gum, starch, paste, etc., added to the dye. The name calico is derived from Calicut, a town in the Indian district of Malabar, where at one time calico printing was practised. Hollow copper rollers are used for the printing, the patterns being etched on the cloth, and the colours being carried by films on the rollers by passing through the colour boxes suitably arranged.

Machines are now made by means of which as many as sixteen different colours can be printed at one time.

Mordants are used for fixing the colours as may be necessary, and a dressing or "finished" appearance is given to the cotton goods by treatment with some adhesive, such as starch or dextrine; "weighting" being given by admixture of barium sulphate, gypsum, or china clay, etc. (See article in Chambers' Encyclopædia.)

"CALLACTITE"—A colloid acid-proof material prepared from hard pitch by dispersing it in a ball mill with an equal volume of water in association with from 0·1 to 0·25 per cent. of resin soap. The resulting product is then mixed with about an equal quantity of asbestos or cellulose fibre pulp, thus coagulating the pitch upon the fibre, after which the product is fashioned into sheets on a paper machine, and these are compressed while in a heated state. It is described as a material which can be manipulated without splitting or cracking, is a good electrical conductor, is acid-proof, and can be used as a roofing material, etc.

CALOMEL (**Mercurous Chloride**)—See Mercury Compounds.

CALORIE—See Heat and Foods.

CALORIFIC VALUE—The amount of heat evolved by combustion of a unit quantity of substance—coal, for example—under standardized conditions, and expressed in calories per gramme or British Thermal Units. (See Heat.)

CALORIMETERS—Appliances for measuring the heat changes in chemical interactions. There are a number of forms, a common one consisting of a metal vessel immersed in water, which is warmed or cooled accordingly. Particular appliances of this kind, useful for determining the calorific values of fuels, are known as the "Berthelot-Mahler" bomb; the "Scholes" bomb calorimeter. The "Simmance" and the "Thomas Recording Gas Calorimeter" are among the best-known gas calorimeters, the last named of which is described in the *Analyst,* 1928, **53,** 385. (See also *C.T.J.*, 1925, **76,** 299; M. Barash on "Gas Calorimetry" (*Ind. Chem.*, 1928, iv., 336); J. S. G. Thomas on "Gas Calorimetry" (*Chem. and Ind.*, 1928, **47,** 829; *B.C.A.*, 1928, B, 591); *The Modern Calorimeter,* by W. P. White (Chem. Catalog. Co., Inc., N.Y.); and Heat.)

CALORIZING—See Metals.

CALX—The residual matter resulting from calcination of mineral matter.

CAMBIUM—Embryonic cells concerned in the production of other cells of plants.

CAMOMILE—See Chamomile.

CAMPHENE ($C_{10}H_{16}$) *d* and *l* is a colourless, crystalline terpene of sp. gr. 0·8446, m.p. 49·5° C., and b.p. 157° C., prepared by treating pinene hydrochloride with alcoholic potash. It does not yield camphoric acid when subjected to the action of nitric acid, is soluble in alcohol and ether, and used in making camphor substitutes. (See Terebene.)

CAMPHOR ($C_{10}H_{16}O$ or C_9H_6CO)—A ketonic body of dextro-rotatory character, being the well-known natural product of characteristic odour formed in camphor-trees (*Laurus comphora* or *Cinnomomum camphora*) which grow in China, Formosa, Japan, and New Zealand, and obtained by distillation of the wood and all parts of the trees. The total output of camphor from Japan and Formosa for the year ended March 31, 1918, was 4,854,000 kilos, or approximately 4,777 tons.

The origin of camphor in the trees is subject of a paper by T. Yahagi (*B.C.A.*, 1928, A, 1290); see also West and Taguibao (*B.C.A.*, 1930, B, 484). It is accompanied by camphor oil, a mixture of hydrocarbons of the terpene class. Camphor is soluble in alcohol and ether, crystallizes in glistening prisms, m.p. 179° C., b.p. 204° C., sp. gr. 0·986 to 0·996, i.v. 0·1, and can be readily sublimed. By reduction it yields cymene ($C_{10}H_{14}$), and by oxidation with nitric acid it yields the dibasic camphoric acid ($C_{10}H_{16}O_4$ or $C_8H_{14}(CO_2H)_2$).

A lævo-modification occurs in *Matricaria Parthenium.*

Considerable quantities of camphor are made synthetically from pinene ($C_{10}H_{16}$) (the chief constituent of German and American turpentine). Pinene is first of all converted into solid hydrochloride by the action of hydrochloric acid gas, and the white crystalline product (having itself a camphor-like odour) is changed into camphene by ammonia, pyridine, or any one of a number of available methods for removing the HCl constituent. The camphene thus prepared is next hydrated into borneol ($C_{10}H_{17}.OH$) by heating with glacial acetic acid and about 2 per cent. of sulphuric acid, and that is finally transformed

CAMPHOR (*Continued*)—

into artificial camphor by oxidation with air, oxygen, ozone, chromic acid, or other agent; or by dehydrogenation brought about by passing the vapour of the borneol over finely divided copper heated to from 300° to 330° C., thus splitting it up into hydrogen and camphor. In the process used at the Vaugouin plants near La Rochelle, tetra-chlorophthalic acid is condensed with pinene, and the non-volatile dibornylic ester thus produced is saponified (after eliminating the secondary volatile products by steam) to produce borneol, which is then oxidized and the tetra-chlorophthalic acid recovered. (For further details see article by J. McLang (*C.T.J.*, 1925, **77**, 327; 1926, **78**, 498); J. Schwyzer (*B.C.A.*, 1930, B, 1141); and P. Schorigin (and another) (*B.C.A.*, 1932, A, 165).)

Camphor is largely used in the manufacture of celluloid and other industries, also as a vermifuge and in medicine. The only observable difference between the natural and the artificial camphor is that the former rotates the polarized light ray, while the latter is optically inactive.

For certain applications some phosphoric esters are employed as camphor substitutes (see A. Bresser, *Ind. Chem.*, 1929, v., 507). A general review of the camphor situation emanating from the U.S.A. is commented on in the *C.T.J.*, 1930, **86**, 398, and Sherwood and Short give an account of the New Zealand production of camphor and camphor oil (*J.S.C.I.*, 1931, **50**, 195 T).

CAMPHOR OIL is a by-product obtained in the fractional distillation of crude camphor oil from *Cinnamomum camphora,* and is a mixture containing pinene, cineol, phellandrene, and some camphor in solution. It has a sp. gr. of about 0·87 to 1·00 at 15° C., ref. ind. 1·465 to 1·481 at 20° C., is soluble in alcohol and ether, and is used in perfumery, also as a substitute for turpentine and for illumination.

CAMPHOR WOOD OIL is sometimes supplied in the form of a yellow crystalline mass, soluble in alcohol and ether, but otherwise as a liquid, and is furnished by dry distillation of the camphor-tree wood (*Dryobalanops aromatica*). It is used in perfumery.

The oil distilled from the leaves of Indian-grown trees contains pinene, dipentene, safrol, cineol, terpineol, and caryophyllene, but cineol is stated to be absent from the oil distilled from the twigs. The wood oil is stated to be similar to that produced elsewhere; it contains safrol, eugenol, carvocrol, and other substances, but not cineol, and is used in Japan as raw material for the manufacture of heliotropin from the safrol contained in it.

CAMPHORIC ACID ($C_{10}H_{16}O_4$ or $C_8H_{14}(CO_2H)_2$) is prepared by the oxidation of camphor ($C_{10}H_{16}O$) with strong nitric acid, and is a white crystalline dibasic acid, of m.p. 208 °C., slightly soluble in cold water, fairly so in hot water, easily dissolved by alcohol, and used in making celluloid articles. Modifications of it include four optically active and two optically inactive forms. (See Racemic Compounds.)

CAMPHORIC PEROXIDE—See "Sanitas" Oil.

CAMWOOD—See Barwood.

CANADA BALSAM—See Balsams.

CANANGA OIL—See Ylang Ylang Oil.

CANCER AND CHEMICALS—See Pitch.

CANDELILLA WAX—See Waxes.

CANDLEBERRY WAX (Bayberry)—See Waxes.

CANDLE-NUT OIL (Lumbang Oil)—Made in the Philippine Islands from the fruits of the candleberry tree (*Aleurites moluccana* and *A. trisperma*). The kernels yield an oil of marked drying quality, making up 63·7 to 66 per cent. of their weight. It is liquid at 18° C., of pale yellow colour, sp. gr. at 15°/15° 0·928, acid value 1·3, sap. v. 195, i.v. 158, N_D^{40} 1·4703; used in the paint, soap, and varnish trades, also as an illuminant and sometimes as an adulterant of Tung oil, but is not edible on account of its purgative properties.

The oil is stated to have the following composition: glyceryl linolenate 6·5 per cent., glyceryl linolate 33·4 per cent., glyceryl oleate 56·9 per cent., glycerides of solid acids 2·8 per cent., and to behave much like linseed oil upon oxidation, while the residual cake left after extraction of the oil is valuable as a fertilizer of high nitrogen content (7 to 9 per cent.). The results of an examination of Malayan Lumbang oil are given by T. H. Barry (*J.S.C.I.*, 1929, **48,** 289 T), and an analysis of the Philippine oil by Cruz and West (*B.C.A.*, 1930, B, 825).

CANDLES are made of palm oil and other solid fatty acids, with or without admixture of waxes such as paraffin wax or ozokerite, and provided with plaited wicks. The addition of wax gives hardness to the candles.

CANE SUGAR—See Sugar.

CANE WAX—See Waxes (Sugar Cane).

CANELLA BARK—Of the *Canella alba,* or so-called wild cinnamon tree (West Indian Islands), belonging to the gamboge order (Clusiaceæ); imported from the Bahamas.

CANELLA OIL—A colourless spicy oil, distilled from the bark of *Canella alba* (of the gamboge order), resembling clove and cajuput oils in odour; containing eugenol, cineol, etc.; sp. gr. 0·92 to 0·935; soluble in alcohol, etc., and used in medicine; yield is 1 per cent.

CANNABIS INDICA—See Gums and Resins (Cannabis Indica).

CANNABIS SATIVA—See Hempseed Oil.

CANNING—See Food Canning (p. 365).

CANTHARIDES or SPANISH FLIES (*Lytta vesicatoria*)—Coleopterous insects collected in South Russia, Galicia, Rumania, Italy, and Spain, used in medicine for vesicating purposes in the forms of tinctures and plasters, also for compounding hair tonics. The active principle is a poisonous, crystalline substance insoluble in water named cantharidin ($C_{10}H_{12}O_4$), which is prepared from these insects or from the Chinese *Mylabris cichorii* by digestion with ether or alcohol, or a mixture of these two solvents.

The American "blister beetle" (*Macrobasis albida,* Say) is stated to

CANTHARIDES (*Continued*)—
yield from the dried material by direct sublimation from 0·6 to 1 per cent. of free cantharidin and 4 to 5 per cent. of total cantharidin. The eggs contain the larger proportion. (See also Iyer and Guha, *B.C.A.*, 1931, B, 993.)

CAOUTCHOUC—See Rubber.

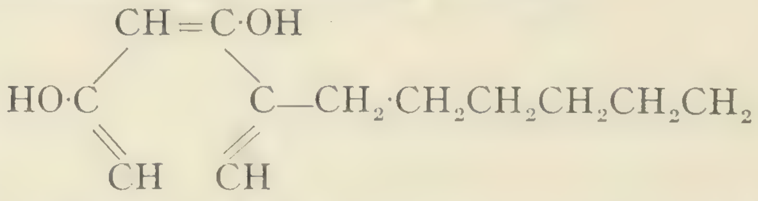
CAPILLARY ATTRACTION, or surface tension effect, depends upon the adhesion or cohesion of fluids to solids, and is closely akin to adsorption, as instanced by a burning night-light in which the melted wax flows to the burning wick. Water is supplied to the roots and stems of growing plants by capillary attraction. The ascent of water in a capillary tube above the general level is slow, whilst that of acetone is rapid, the rise being due (it is suggested by Leslie) to the force exercised by the walls of the tube upon the water molecules extending to some depth into the liquid.

Capillary attraction has also been defined as the natural tendency of liquids to contract to a minimum, due to potential energy, decreasing as the temperature rises. (See E. K. Carver and F. Hovorka on a method for accurate determinations of surface tension (*J. Amer. C.S.*, 1925, xlvii., 1325-1328); R. S. Burdon (*Chem. and Ind.*, 1925, **44,** 1251); N. K. Adam (with others) on a "Comparison of Methods of Measuring the Polarity of Surfaces" (*J.C.S.*, 1925, cxxvii., 2793); H. Mills on "Capillary Activity in Aqueous Solution" (*J.C.S.*, 1932, p. 419); *Surface Tension*, by R. S. Willows (J. and A. Churchill); also Lubrication and Colloid Chemistry.)

CAPRIC ACID ($C_{10}H_{20}O_2$ or $C_9H_{19}COOH$)—A member of the normal fatty acids, present in cow's and goat's milk and cocoa-nut oil, and formed by the oxidation of oleic acid; m.p. 31° C., b.p. 269° C. It is soluble in alcohol.

CAPROIC ACID ($C_6H_{12}O_2$ or $C_5H_{11}COOH$)—A member of the normal fatty acids contained in goat's milk and cocoa-nut oil; often forms one of the products of the oxidation of higher acids of the same series. It is a colourless oily body of m.p. 8° C., b.p. 205° C., sp. gr. 0·931 at 15° C., with a sudorific odour, and is soluble in alcohol and ether.

"CAPROKOL" (**Hexylresorcinol**)—A urinary antiseptic:



CAPRYLIC ACID ($C_8H_{16}O_2$ or $C_7H_{15}COOH$)—A colourless fatty acid of unpleasant odour contained in cow's milk, goat's butter, cocoa-nut oil, Lemberg cheese, and some fusel oils; sp. gr. 0·9185, setting-point −3·6° C., m.p. 16° C., b.p. 236° C.; soluble in water, alcohol, and ether.

CAPSICUM (**Cayenne Pepper, Chillies, Red Pepper**)—The dried ripe fruit of *Capsicum fastigiatum*, a genus of Solanaceæ, indigenous in

CAPSICUM (*Continued*)—

South India, Sierra Leone, Zanzibar, and South America. Though used as a condiment in the main, it is also employed medicinally as a counteragent to the relaxing effects of heat and also to check the drink-craving of dipsomaniacs. The pungent principle of Spanish pepper (the fruit of *Capsicum annum*) is a substance named *capsaicin* ($C_{18}H_{28}O_3.N$). The name "capsicine" has been applied in America to an oleo-resinous extract from *Capsicum baccatum*.

Experimental work started with the object of preparing substances exceeding capsaicin in pungency is described by Jones and Pyman (*J.C.S.*, 1925, cxxvii., 2588).

CARAGHEEN MOSS—See Sea-weeds.

CARAMEL—A dark-coloured substance, soluble in water, made from cane-sugar by heating above its melting-point (160° C.) up to about 180° to 190° C. (or from glucose by heating to 198° C.), when it is said to lose two molecules of water and caramelan ($C_{12}H_{18}O_9$) is formed—a brown colouring matter which is the characteristic principle of caramel or sugar dye. It can also be prepared by the action of a strong solution of potassium or sodium hydroxide upon glucose solution, and again by heating starch syrup, glucose, molasses, etc., with 10 per cent. glacial acetic acid and acetic anhydride or sodium acetate under reflux, precipitating the caramel thus formed by means of sodium carbonate (U.S. Patent, No. 1,316,019). The so-called "ammonia process" for the manufacture of caramel consists in bringing ammonia in the form of gas or strong solution into contact with fused dextrose or dextrose in solution at a temperature of from 35° to 40° C., when combination occurs, resulting in the formation of glucose-ammonia, and when the ammonia is removed by heating to 100° C., a mixture of aldoses and ketoses in equilibrium is formed. Ammonia reacts much more vigorously with lævulose solutions than those of dextrose, and the reaction is accompanied by instantaneous darkening and decomposition. Caramel is used as a colouring and flavouring material and in confectionery. See H. Drake-Law, *J.S.C.I.*, 1927, **46**, 428 T.)

CARAWAY OIL—The dried seeds of *Carum carvi* (indigenous in Holland and grown in Moravia and Germany) yield 4 to 7 per cent. of a thin, pale yellow oil, soluble in alcohol and ether, containing 40 to 50 per cent. carvone ($C_{10}H_{14}O$) and some dextro-limonene. Sp. gr., 0·90 to 0·92 at 15° C.; opt. rot., +75 to +85; ref. ind., 1·4867 to 1·4970 at 25° C.; used in medicine, perfumery, and in flavouring.

CARBAMIDE—See Urea.

CARBAZOLE (**Carbozol**) ($C_{12}H_9N$ or $(C_6H_4)_2NH$), the imide of diphenyl, is a constituent of coal-tar and crude anthracene. It is a white, crystalline substance of m.p. 246° C., b.p. 351·5° C.; is readily sublimable, and can be formed by passing the vapour of diphenylamine through red-hot tubes. Another process for its manufacture consists in heating the crude article with an alkali metal or hydroxide in the presence of an indifferent solvent, such as naphthalene or toluol, under pressure, and at a temperature below the melting-point of the alkaline carbonate. The

CARBAZOLE (*Continued*)—

solvent is subsequently removed, and the alkali carbazole decomposed by boiling with water. (See B. V. Maksorov, *B.C.A.*, 1929, B, 805.)

Carbazole is soluble in alcohol and ether, but insoluble in water, and is used in the manufacture of dyestuffs.

CARBIDES—Compounds of carbon with metals such as aluminium carbide (Al_4C_3), calcium carbide (CaC_2), and cast-iron (a quality of which can be made corresponding with the formula CFe_2). Many can be made by heating the metals or their oxides with carbon, and they are good conductors of electricity, excepting silicon carbide. The niobium and tantalum carbides have very high m.p.s (4,000° to 4,100° C.). (See Gluud (with others) (*B.C.A.*, 1929, A, 1409); Fischer and Bahr (*B.C.A.*, 1930, A, 1540); Agte and Alterthum (*B.C.A.*, 1931, A, 170); and Calcium Carbide.)

CARBINOLS—Alcohols in which the three hydrogen atoms (as methyl alcohol) are wholly or partly replaced by alkyl radicals such as tertiary butyl alcohol $(CH_3)_3C.OH$ = trimethyl carbinol.

CARBOBRONZE—An alloy of about 92 per cent. copper, 8 per cent. tin, and 0·3 per cent phosphorus; used in the dyeing, tanning, and some other industries.

"CARBOCYCLIC"—See Cyclic.

"CARBOGEN"—See Carbon Oxides.

CARBOHYDRATES constitute a large body of organic compounds of great value as foods, built up (for the most part) of carbon with hydrogen and oxygen in the proportion in which the two last-named elements exist in water—hence the name. They include sugars, starches, and celluloses, but there are other carbohydrates such as rhamnose ($C_6H_{12}O_5$), in which the hydrogen and oxygen constituents are not present in the water proportions.

At one time they were classified as glucoses (of the type $C_6H_{12}O_6$), saccharoses ($C_{12}H_{22}O_{11}$), and amyloses $(C_6H_{10}O_5)_n$. By another grouping, they are divided into three great classes—viz., the monosaccharides, including arabinose ($C_5H_{10}O_5$), glucose and fructose, which are isomeric bodies ($C_6H_{12}O_6$); the di- and trisaccharides, which may be viewed as anhydrides of the first group (that is, devoided of 1 or 2 molecules of water respectively), such as cane-sugar ($C_{12}H_{22}O_{11}$), which must then be regarded as the anhydride of glucose; and the polysaccharides (polysaccharoses or polyoses), including the starches and the celluloses, from which a monosaccharide can be obtained by hydrolysis. The so-called monosaccharides are sweet, soluble in water, and do not crystallize—at any rate, not very well; the di- and trisaccharides are also sweet, and crystalline; whilst the so-called polysaccharides are not sweet, insoluble in water, and non-crystalline.

They have also been classified as: (1) Reducing sugars, which are unaffected by hydrolysis; (2) glucosidic compounds, which yield at least one reducing sugar upon hydrolysis; and (3) polysaccharides, all of which are inter-related, and there is a current view to the effect that the whole range of sugars and polysaccharides arise from glucose.

CARBOHYDRATES (*Continued*)—

As to their food values, they have been classified under the groups of starch and soluble sugars, hemicelluloses and fibre. (See paper by S. Dixon (*Chem. and Ind.*, 1930, **49**, 665).)

The constitution of polysaccharides and the classification of the sugars form the subjects of papers by J. C. Irvine (with others) (*J.C.S.*, 1926, pp. 1488 and 1502, and J. G. Maltby, p. 1629, respectively); and the structural study of carbohydrates by J. C. Irvine (*Chem. Reviews, Amer. Chem. Soc.*, September, 1927, and *Chem. and Ind.*, 1932, **51**, 263); W. N. Haworth (*J.S.C.I.*, 1927, p. 295 T); Hampton, Haworth and Hirst (*J.C.S.*, 1929, p. 1739); and E. F. Armstrong (*Chem. and Ind.*, 1931, **50**, 534).

The mono compounds are named according to the number of CH_2O groups present in them—viz., as monoses, bioses, etc.—the hexose group having therefore six carbon atoms.

The simple sugars combining the chemical properties of alcohols and aldehydes are now termed *aldoses,* while those which are at the same time like alcohols and ketones are styled *ketoses,* and contain the group carbonyl (:C : O).

Evidence has been forthcoming that certain sugars can be synthetically produced from formaldehyde (built up from carbon dioxide and water) by the polymerization of the first-named substance by the agency of alkali, hydroxides, and carbonates, and Baly has succeeded in building up carbohydrates by irradiation of pure nickel carbonate in pure water by a stream of carbon dioxide, the light coming from an ordinary tungsten filament lamp. (See Vegetation.)

Many of these substances are described under their several names. As a class, the carbohydrates char when heated strongly, and give off an odour of burnt sugar. The use of carbohydrates in connection with production of alcohol is dealt with elsewhere. (See *The Constitution of Sugars,* by W. N. Haworth (E. Arnold and Co., London), and *Carbohydrates and Alcohol,* by S. Rideal (Baillière, Tindall and Cox, London); also Alcohols, Cellulose, Glucose, Photocatalysis, Starches, Sucrose, and Sugar).

CARBOLIC ACID—Commercial liquid carbolic acid is a straw-coloured liquid of about 1·08 sp. gr., and is a mixture of phenol (C_6H_5OH) and cresol ($CH_3.C_6H_4.OH$) with some other associated substances, all of which are termed "tar acids." It is separated from the cruder coal-tar distillates, from which it is prepared, by extraction with caustic soda, the saponified liquid thus obtained being afterwards treated with sulphuric acid which combines with the soda and sets free the "tar acids." (See Phenols and Tar Acids.)

CARBON and ORGANIC MATTERS—

Carbon (C) **and its Compounds**—Atomic weight, 12·003; sp. gr. (amorphous variety), 1·57; melting point, formerly reported as about 3,760° C., and more recently as 3,482° C. Carbon is well known in the three forms of the diamond, graphite (plumbago), and charcoal. It is also found widely distributed in nature, not only as a constituent of animal and vegetable tissues, and in the air in the form of carbon

CARBON and ORGANIC MATTERS *(Continued)*—

dioxide (CO_2), but also in combination as calcium carbonate ($CaCO_3$) in the rocks known as limestone and dolomite.

The diamond is the purest form of crystallized carbon (crystal system No. 1 and sp. gr. 3·5). They are for the most part colourless, but some are variously tinged and others black, very hard and exhibit the lowest compressibility on record. Deposits are found in South Africa, Brazil, India, and elsewhere. They crystallize readily on garnet, iron-pyrites, olivine, and ilmenite ($FeTiO_3$), and these minerals, as also graphite and "boart," are frequently found as inclusions in diamonds, such being known as "white-spots," "cross-grain," and "knots," causing strain and liability to fracture.

Black diamonds ("carbonado") and the inferior colourless "boart" ("bort") are used for rock-drilling and diamond-cutting respectively.

As to the origin of diamonds, one surmise is that they have crystallized out from carbon held in solution in masses of molten iron at a very high temperature and pressure, and Mossan has shown that they can be produced from pure iron and charcoal under suitable conditions when exposed to a current of 1,000 ampères in an electric furnace.

The diamond is converted into graphite in the heat of the electric arc, and according to Lebeau and Picon the transformation *in vacuo* occurs between 1,500° and 1,900° C., while above 2,000° C. the change is much more rapid.

The great rigidity of the diamond is explained by Bragg as due to the fact that the bonds which tie the links together are exerted in every direction.

Colourless diamond has a determined heat of combustion $7{,}873 \pm 4$ cal./g. When strongly ignited, diamonds burn up in the presence of air or oxygen into carbon dioxide (CO_2), just as charcoal does at a lower temperature, thus proving them to consist of carbon. Atomic form with special reference to the carbon atom is the subject of a book by E. G. Price (Longmans, Green and Co., London).

Graphite (crystal system No. 3 and sp. gr. 2·2 to 2·3) is found plentifully in nature in Austria, Bohemia, Canada, Japan, Siberia, Spain, California, Ceylon, Germany, India, Italy, Korea, Mexico, Madagascar, Greenland, Moravia, the U.S.A., Russia, the Kenya Colony, and elsewhere, including Grampound in Cornwall and Borrowdale in Cumberland where it is used in making pencils, although the Keswick pencil works now use imported graphite. Madagascar occupies a predominant position in the supply of crystalline flaked graphite; the exports from that country having amounted to 9,221,662 kilos in 1930. It is a shiny, soft, nearly black substance, consisting largely of carbon (varying from 50 to 97 per cent.), and on account of its refractory character is used for the manufacture of so-called plumbago crucibles—that is, crucibles made of fire-clay mixed with graphite—employed for making "crucible steel," various alloys, etc. It is also employed for making arc-light carbons; as a polish and coating (black-leading) for iron articles to prevent rusting; in admixture with rubber as an acid-proofing coating,

CARBON and ORGANIC MATTERS (*Continued*)—

and as a paint pigment and lubricant. The world's production in 1919 was upwards of 156,000 tons.

In a pure form it can be obtained by the carbonization of artificial silk threads in an atmosphere of coal-gas, and subsequent heating to incandescence at from 1,500° to 2,000° C., when surrounded by either a gaseous or liquid hydrocarbon or hydrocarbon derivative such as hexachlorobenzene at 3 mm. mercury pressure, or carbon tetrachloride at 15 mm. pressure, followed by finally heating to about 3,500° C. in carbon monoxide. The resulting filaments can be bent like lead. The carbon produced by the catalytic decomposition of carbon monoxide is also said to be of graphitic nature (T. Watanabe, *B.C.A.*, 1929, A, 773). (See Arndt and Pollack on "Graphitization" (*B.C.A.*, 1932, B, 134) and Kish.)

According to Lowry and S. O. Morgan (*J.C.S. Abs.*, 1925, ii., 1053), graphite is capable of an adsorptive capacity equal to $\frac{1}{3}$ or $\frac{1}{4}$ that of the best charcoal. The melting-point of graphite has been estimated as 3,800° ± 100° abs. from observations of carbon rods heated in an atmosphere of argon, and by other determinations as 3,845° ± 45° abs. Some further details respecting graphite and its uses are given in an article by A. Seton (*Chem. and Ind.*, 1930, **49**, 493).

Carbon is also known in impure form as a constituent of coke, lampblack, and animal charcoal (bone-black), and this last-named substance is used as a decolourising agent in refining sugar, glycerine, fats, etc., having the property of taking up many kinds of colouring matters. In this property, birch charcoal-dust is stated to be equally efficient. Animal charcoal prepared from bones contains about 81 per cent. of calcium and magnesium phosphates and calcium fluoride, from 7 to 8 per cent. of calcium carbonate and other salts, and only from 10 to 11 per cent. of carbon.

Charcoal (which has been shown to be really crystalline in structure) has the property of absorbing gases very readily, particularly when cooled, wood and peat charcoal being superior in this respect to animal charcoal. The absorptive power of wood charcoal is notably increased by prolonged heating, and the denser charcoals—notably those from palm-nut, cocoa-nut, and fruit stones—are the most efficient gas absorbents. The following table shows the capacity of absorption of various gases by boxwood charcoal:

Ammonia gas	90 volumes.
Hydrochloric acid gas	85 ,,
Sulphur dioxide gas	65 ,,
Hydrogen sulphide gas	55 ,,
Carbon dioxide gas	35 ,,
Oxygen gas	9·25 ,,

(See Colloid Chemistry (Adsorption, p. 227).)

Most of the carbon black used in the U.S.A. in the preparation of inks, polishes, pigments, tarpaulins, carbon papers, phonograph records, black leather, insulating materials, and the rubber industries, is now

CARBON and ORGANIC MATTERS (*Continued*)—

made by the incomplete combustion of natural (hydrocarbon) gas in air, at a temperature of about 2,000° F., the production in 1923 being reported at 138,262,648 lbs. (See Gas (Natural).) It is of a fluffy, velvety black character, and about 16 per cent., at most, of the total carbon is recovered) by collection upon a metallic surface held in contact with the flame). A large part of the gas, being burned in the form of a luminous flame as the source of heat, is necessarily consumed in the process. A greater proportion of the 30 lbs. carbon present in 1,000 cubic feet of the gas can be obtained, but not more than about 5 lbs. if the production of graphite (which is undesirable) is to be avoided.

By heating sugar for a prolonged period to 900° C. carbon is obtained containing only minute traces of hydrogen and oxygen, and approaching more nearly to elementary purity than any other form excepting the diamond and purified graphite. This carbon black possesses advantages over lamp-black for making printing ink, and is stated to be of great value for improving the wear-resistant power and resiliency of rubber used for making automobile tyres. The largest consumption of carbon black is in this industry, and it has been proposed to utilize the crude carbon left after combustion of old tyres for the same purpose.

A very pure grade is stated to result from treating charcoal with selenium oxychloride (which dissolves any hydrocarbons) and subsequent washing.

Certain activated carbons are made by subjecting carbonaceous matters (such as nut-shells) of high density and stone-cell structure to a process of distillation at above 700° C., and then submitting the residual product to the action of steam whilst still hot, or that of other oxidizing gas. This treatment, without causing appreciable combustion of the carbon, removes hydrocarbons, which are said to render the carbon inert. As thus prepared, it is used in gas masks; for clarifying and decolorizing liquids; in benzol recovery plants for the extraction of hydrogen sulphide from coal and coke-oven gases; the production of sulphur dichloride; the removal of fusel oil from alcohol; and for assisting in the production of high vacua.

In the "Bayer" process, a paste of peat, sawdust, etc., with zinc chloride is pressed into rods which are then broken and calcined in a rotary furnace, while in the "Urbain" process phosphoric acid is used; this upon ignition at 1,200° C. is reduced to phosphorus, which is distilled over and burned. (See Pearson and Reisemann, *B.C.A.*, 1930, B, 42.)

Berl and Burkhardt have prepared active carbon from various organic compounds, including potassium naphthalene-disulphonate, by dropping them into a steel cylinder heated to 1,000° C. and quenching with water (*B.C.A.*, 1930, B, 593).

The activity of charcoal depends, according to Boutarie and Perreau, to some extent upon the temperature of baking (*B.C.A.*, 1928, B, 1086). See also J. Simonin (*B.C.A.*, 1930, B, 748).

The commercial methods of activating carbon have been summed up as follows:

CARBON and ORGANIC MATTERS (*Continued*)—

1. By heating *in vacuo* at from 300° to 1,200° C.
2. By exposing to superheated steam at from 300° to 800° C.
3. By heating in contact with reducing gases at from 500° to 800° C.
4. By combining the methods (2) and (3).
5. By treatment with solutions of certain salts, then reheating, washing, and purifying the resultant carbon.

There is, however, no one type of activated carbon that is universally and equally effective for all purposes.

An electrical method of preparing a carbon black which compares favourably with the better grades of other varieties consists of passing natural gas through an electric arc, and the arc process can also be used in respect of such liquids as kerosene, benzene, creosote, and alcohol.

There is also a patented process for obtaining active carbon from carbon monoxide by action of a catalyst such as finely divided iron or iron oxide, finely divided carbon and carbon dioxide resulting. (Brit. Patent, No. 246,130, J. G. Clarts.)

The activity of a carbon can, it is stated, be evaluated by its power of absorbing phenol (Ruff). (See O. Ruff, *C.T.J.*, 1925, **77,** 323.) The nature of active carbon is the subject of a paper by H. H. Lowry, who takes the view that the activity is best defined by the amount of gas absorbed per "unit area" and not per "unit weight" (*B.C.A.*, 1930, A, 286).

There is little doubt that the properties of active charcoals are dependent upon the extent (per unit mass) of their surfaces in relation to the chemical substances to be dealt with and that their absorptive power bears no relation to the ash content.

The process of activation is considered by M. and L. Jacqué to be the freeing of the groundwork from deposits of inactive carbon, the latter resulting from the cracking of hydrocarbons during carbonization (*B.C.A.*, 1929, B, 914).

It would appear that oxygen may be absorbed on a charcoal surface forming three types of surface compounds—one removable only as oxides of carbon at extremely high temperatures; another removable as oxides by evacuation or by fusion with sodium carbonate; and the third formed in larger quantities by absorption at low temperatures recoverable as oxygen. (See E. K. Rideal and W. M. Wright, *J.C.S.*, 1925, cxxvii., 1347.)

The activity of carbons prepared from carbohydrates varies, and it has been shown that the moisture content exercises a very considerable influence, but the greatest is that of the carbon obtained from glucose, and the least that of the variety from lævulose. The ultimate sorptive capacity, however, of all of them is the same.

Among other uses to which activated carbon is applied is that of sulphur removal from gases, removing disagreeable fumes given off in various processes, such as those for making fertilizers, glue, the recovery of fats, and in the tanning and varnish industries, by passing them, after cooling, direct into a vessel containing the carbon. When

CARBON and ORGANIC MATTERS *(Continued)*—

the carbon is saturated, it may be revivified by passing steam through it at a pressure of 15 to 25 lbs. (See *C.T.J.*, 1928, **83,** 478.)

So-called "thermatomic carbon" is prepared by cracking methane over heated brickwork; it has a sp. gr. $2\frac{1}{2}$ times that of first-grade carbon black, the average size of its constituent particles being from 0·1 to 0·2 microns. It is dark grey in colour, contains 0·1 to 0·2 per cent. ash, and 0·7 per cent. matter removable by solvents, but has no activating effect on organic rubber accelerators. As a rule, active carbons can be economically revivified by adequate cleansing and burning.

The various types of prepared carbons include Acetylene Black (a Canadian high-grade quality for electrical uses); "Acticarbone" prepared from wood charcoal); "Bastanat" (from fish), "Batchite," "Bayer," "Bideford Black," "Bone Black"; "Carboraffin" (zinc chloride prepared); "Carbrox" (from rice or cotton); "Darco" (from lignite); "Delchowyte" (from peat); "Dorsite" (from cocoa-nut shells); "Eponite"; "Filtchar," "Flaming," "Flandac," "Hamonite" (from peat); "Karbos" (from sawdust); "Kelpchar" (from sea-weed); "Littoral"; Mineral Black; "Molaschar"; "Norit," "Prussiate Char," "Purit," "Smoke Black," "Suchar" and "Sulphite Carbon" (prepared from sulphite cellulose liquors).

References: A method for the identification of "Norit" and other wood charcoals by H. G. Tanner, based upon the microscopical examinations of their chars (*Ind. Eng. Chem.*, 1925, xvii., 1191); *C.T.J.*, 1923, **73,** 161, and 1925, **76,** 693; A. B. Page on "Activation of Wood Charcoal" (*J.C.S.*, 1927, p. 1476); S. J. Gregg on "Heat of Adsorption of Gases by Charcoal" (*J.C.S.*, 1927, p. 1494); J. T. Strachan (*Chem. and Ind.*, 1928, **47,** 1203); S. R. Price on "The Activated Carbons 'Acticarbone' and their Industrial Applications" (*Ind. Chem.*, 1930, vi., 145); Evans, Pearson, and Reisemann on "The Manufacture and some uses of Active Carbon" (*C.T.J.*, 1929, **85,** 567); J. Vasatko on "Testing the Activity of Decolourizing Carbons" (*B.C.A.*, 1930, B, 1125); D. Parkinson on "Some Properties of Carbon Black" (*B.C.A.*, 1931, B, 51); J. C. Liddle on "Solvent Recovery by the Bayer Active Carbon Process" (*Chem. and Ind.*, 1932, **51,** 3); M. S. Shah on the "Combustion of Charcoal" (*J.C.S.*, 1929, pp. 2261-2692); Alexeevski and Musaken, who express the opinion that the absorptive properties of wood charcoal are enhanced by the agency of volatile oxidants (*B.C.A.*, 1930, A, 851); M. Schofield on "Active Carbons and their Applications as Catalytic Agents" (*Ind. Chem.*, 1930, vi., 332); C. H. Butcher on "Carbon Black, Lamp Black, and Bone Black" (*C.T.J.*, 1930, **87,** 399, 454, and 501); A. E. Williams on "Activated Vegetable Carbons" (*C.T.J.*, 1931, **89,** 423); *Industrial Carbon,* by C. L. Mantell (Chapman and Hall); Bone Black, Charcoal, and Lamp Black.

Water is not adsorbed by charcoal, but absorbed or held by capillary action, and the adsorptive power of charcoal varies with the method of its preparation within very wide limits.

All vegetable matters consist, in part, of carbon in chemical combination, and when they are burned with an insufficient quantity of air

CARBON and ORGANIC MATTERS (*Continued*)—

or oxygen a mass of "char," or carbon, remains behind. For example, when wood is burned in a smothered sort of way—that is, with an insufficient quantity of air or oxygen—a part of it is left behind in the form of wood charcoal; in fact, that is how charcoal is prepared.

"Char" not only adsorbs colour from complex solutions, but will retain—sometimes with great avidity—many mineral and organic compounds, such as the alkaloids, for which, indeed, purified animal black is an antidote.

Vegetable Matters—There are an immense number of vegetable organic products, many of which can be built up artificially by synthetical processes. Amongst these substances may be mentioned formaldehyde, urea, alcohol, glycerol, tartaric acid, indigotine, vanillan, alizarin, coumarin (the odoriferous principle of the Tonka bean), and many perfumes. (See Vegetation.)

We may well be excited to wonder by the marvellous extent and nature of the structures, tissues, colouring matters, and other products that characterize vegetable life, built up out of the constituents of the soil and the air by the living agencies contained in their seeds. They find their parallel in the animal kingdom and the wonderful determining force that causes many salts in a state of solution to crystallize out therefrom in such beautiful geometrical or symmetrical forms as referred to in another section.

Animal Matters—Compounds, of which carbon forms an important constituent, are generally termed *organic,* and all of them are combustible—that is to say, they can be wholly or partially burned up if heated sufficiently in the presence of plenty of air or oxygen and leaving only the ash, consisting of mineral matters which were present before burning.

There are many organic compounds composed of carbon and hydrogen only, termed hydrocarbons, including such substances as methane or marsh-gas (CH_4), acetylene (C_2H_2), benzene (C_6H_6), naphthalene ($C_{10}H_8$), and turpentine ($C_{10}H_{16}$). (See Hydrocarbons.)

Cyanogen (C_2N_2) consists of carbon and nitrogen only.

Many others contain oxygen in addition to carbon and hydrogen, alcohol (C_2H_6O), glycerol ($C_3H_8O_3$), acetic acid ($C_2H_4O_2$), phenol (C_6H_6O), and the carbohydrates being instances of this class.

Another class consists of carbon, hydrogen, and nitrogen, including prussic or hydrocyanic acid (CHN) and aniline (C_6H_7N); and further groups containing oxygen in addition to these three elements, such as urea (CH_4N_2O), indican ($C_{14}H_{17}O_6N.OH_2$), morphine ($C_{17}H_{19}NO_3$), and quinine ($C_{20}H_{24}N_2O_2$).

There are still more complicated organic substances in which other elements exist in combination with carbon, and one or more or those already mentioned, such as sulphur, phosphorus, chlorine, bromine, and iodine.

Other organic compounds of very complex composition exist in the flesh, the brains, and other parts of living creatures, the chief solid

CARBON and ORGANIC MATTERS (*Continued*)—
parts of the living tissues of animals consisting of so-called albumins. (See Albumins.)

CARBON BICHLORIDE—See Tetrachlorethylene.

CARBON BLACK—See Carbon.

CARBON DIOXIDE—See Carbon Oxides.

CARBON DISULPHIDE (CS_2) as ordinarily made is an evil-smelling, heavy, mobile, poisonous, and highly inflammable liquid, which may be prepared by passing the vapour of sulphur over red-hot carbon, the volatile product being condensed in properly cooled vessels. It is also produced when sulphur dioxide gas is passed over wood charcoal heated to from 850° to 900° C. The old process of its manufacture has been superseded by the application of electrical heating, one process using charcoal heated in a shaft between a fixed electrode and a movable one as the resistance. It can be prepared in practically odourless or pleasantly smelling form by first shaking up with mercury, and after separation, allowed to stand for a short time in presence of 2 per cent. pure fat, followed by distillation. It is a colourless, highly refracting liquid which, when pure, boils at 46·25° C., freezes at −116·3° into tetragonal crystals, has a sp. gr. of 1·292 at 0° C., and is soluble in water to the extent of 0·258 g. at 0° C. and 0·195 at 30° per 100 g.

It is manufactured on a considerable scale, and employed in the manufacture of viscose, also as an insecticide, a solvent of caoutchouc and fats, and in processes of extraction of essential oils and perfumes.

It yields a vapour of great insecticidal power in respect of ants, white grubs, mole crickets, moths, and other pests including those which affect stored corn; an atmosphere composed of 1 part vapour and 90 parts of air being fatal to most insects. As applied for Phylloxera treatment, the liquid is introduced into the soil some depth below the surface, so that it slowly volatilizes, the vapour thus reaching the pests against which it is applied in a diffused manner. It is usual to apply about 10 ounces per vine, using half that quantity (150 grammes) in each of two applications ten or twelve days apart. Miscible emulsions of it are also used for destroying the Japanese beetle in the soil without damaging the plants, one such emulsion being made from the disulphide, castor oil, potassium hydroxide, denatured alcohol and water. (See Fleming and Wagner (*B.C.A.*, 1928, B, 703); W. G. Huff (*J.S.C.I.*, 1931, **50,** 169 T; and Drakeley and Baker on "Formation of Carbon Disulphide from Hydrogen Sulphide and Coke" (*J.S.C.I.*, 1930, **49,** 475 T).)

CARBON ELECTRODES, as used for electric furnace work, are of several kinds, being variously made of graphite, coke, charcoal, lampblack, anthracite coal, etc.; others of carbon derived from the baking of coal-tar pitch of m.p. from 150° to 200° F. A good pitch of this character loses nearly all its volatile matter at 600° F. The electrodes are formed by working up the cleaned powdered material, such as coke with tar or pitch, then pressing to the desired shape by ramming the

CARBON ELECTRODES (*Continued*)—
material into moulds, wherein it is calcined in a gas-fired kiln at about 1,100° C., with the exclusion of air. For carbide furnaces, electrodes up to 3 m. long and of 80 cm. diameter, weighing about 2 tons, capable of carrying 8,000 kw., are used in furnaces yielding 50 tons product per day; while for use as anodes in making aluminium the electrodes must be of great purity, giving less than 1 per cent. ash. Acheson graphite is stated to be most suitable for anodes to be used in the electrolytic manufacture of chlorine and caustic soda by the porous diaphragm process. (See K. Arndt, *B.C.A.*, 1925, B, 409.)

CARBON MONOXIDE—See Carbon Oxides and Poisons.

CARBON OXIDES—**Carbon monoxide** gas (CO) is said to be the principal, if not the primary, product when carbon is burned at a bright red heat (Smith and Ebaugh, *J.C.S. Abs.*, September, 1925). It is also produced whenever carbon is burned with an insufficient supply of oxygen to convert it into the dioxide, and may be prepared by passing a stream of the carbon dioxide gas over charcoal heated to redness ($CO_2 + C = 2CO$), and in pure form by heating formic acid with strong sulphuric acid ($CH_2O_2 = CO + H_2O$). It suffers catalytic dissociation at temperatures varying with the nature of the catalyst, 400° C. being necessary when glass forms the only contact surface. Its decomposition in the silent electric discharge has been studied by Lunt and Mumford (*J.C.S.*, 1929, p. 1711), and W. A. Bone has summarized the results of fifty years' experimental research on the influence of steam on the combustion of carbonic oxide in his Liversidge Lecture of 1930 (see *J.C.S.*, 1931, pp. 338-361). It is colourless, poisonous, of m.p. $-211°$ C.; slightly soluble in water, 1 volume of which at 0° C. dissolves 0·0328 volume, and is utilized in a process for the manufacture of the metal nickel. It often occurs at times in coal mines, and is known as *white-damp*. A rescue apparatus for use in cases of carbon monoxide poisoning depends for its efficacy upon the use of so-called "*carbogen*"—that is, a mixture of oxygen with 5 per cent. of carbon dioxide.

It has been demonstrated that a dry mixture of carbon monoxide and oxygen can be made to combine with explosive violence by a sufficiently powerful electrical condenser charge. (See W. Gluud (with others) on its recovery from industrial gases (*B.C.A.*, 1932, B, 180); Gas (Coal), Nickel, Safety Lamps, Synthol, and Water Gas.)

Carbon dioxide is the colourless gaseous product obtained whenever carbon is burned with a sufficiency of oxygen, and admits of condensation into the liquid and solid forms. It can readily be produced by the action of acids upon carbonates, such as calcium carbonate (chalk and marble), and when hydrochloric acid is used in this process the change that takes place is represented as follows: $CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2$—that is to say, the carbon dioxide gas escapes in a brisk effervescence, calcium chloride being left behind in solution. There is also a cheap method for its production based upon the reaction between sodium bicarbonate and sodium bisulphate.

It is one of the constituents of what is called *black-damp* or *choke-*

CARBON OXIDES (*Continued*)—

damp by coal-miners, and often occasions loss of life in mines after explosions.

In solid form known as "Dry Ice" it is now made on a large scale from the liquefied substance by a process of which there are several modifications. In one of these, the liquid is cooled in coils by which it is raised to the top of a chamber in which the pressure is lowered to 6·2 atm. by expansion across an orifice; the resultant mixture of liquid and solid CO_2 is then thrown on to a filter at the floor of the chamber from which the liquid is subsequently removed, leaving in due course a solid block of the "dry ice" (see *Ind. Chem.*, 1928, iv., 119, and 1930, vi., 432). The production in the U.S.A. in 1930 has been estimated at 30,000 tons. It is also made in Canada on a large scale by the "Backhouse" process—that is, by the adiabetic expansion of the cooled liquefied substance. The gas is expanded to a pressure of 15 lbs.; from 50 to 60 per cent. evaporates and is subsequently returned; while the remainder solidifies and is then moulded and pressed into blocks. These are packed in wooden cases and the article constitutes a stable product which can be sold at half the price of the liquefied form, being used for preserving perishable goods and, among other applications, for refrigerating cars making long journeys, 1 part replacing 15 parts of water and 3 parts salt.

It is on record that in the Quebrache district of Mexico's oil fields a natural enormous supply of carbon dioxide gas has been struck which is being used for the production of the solid product.

(See *C.T.J.*, 1927, **80**, 169; *Ibid.*, 1928, **83**, 456; 1930, **87**, 199; *Ind. Eng. Chem.*, October, 1928; D. H. Killefer, *B.C.A.*, 1927, B, 250, and 1931, B, 19.) The process known as the "Carba" is about to be used in Australia. (See *C.T.J.*, 1930, **87**, 159; *Ind. Chem.*, 1931, vii., 127; and G. T. Reich (*B.C.A.*, 1931, B, 717).)

One volume of water at 0° C. dissolves 1·713 volumes of the gas (or 19·75 lbs. per 1,000 gallons of water), which is employed commercially in many ways both as gas and in liquefied forms; amongst other applications, for impregnating water under pressure (making what is called "soda-water") as a fire extinguisher, and for refrigeration. As generated in the fermentation process of beer-making it has an odour of amyl-alcohol, but the gas can be used for the carbonization of beer itself, and when purified it might be used for the gasification of mineral waters. Processes of purification are surveyed in a paper by G. T. Reich (*C.T.J.*, 1931, **88**, 353). Its m.p. is $-57°$ C., and its b.p. under atmospheric pressure is $-80°$ C.

It is sometimes met with in liquid globule form in certain minerals, and is elsewhere referred to as a constant gaseous constituent of the atmosphere (3 to 4 parts per 10,000 parts air) and as a product of respiration. (See Air, Refrigeration, Vegetation, and Ventilation.)

An instrument for its estimation based upon sound velocity is referred to in the *C.T.J.*, 1927, **80**, 491. (See also Recorders.)

Carbonic Acid (H_2CO_3)—This combination of carbon dioxide with water, although itself an unstable body, forms with bases a great series

CARBON OXIDES (*Continued*)—

of well-defined compounds known as carbonates. Thus, by combination with the so-called alkalies and alkaline earths, we get the following series: sodium, potassium, and ammonium carbonates (Na_2CO_3, K_2CO_3, and $(NH_4)_2CO_3$), all of which are soluble in water; and calcium, barium, and magnesium carbonates ($CaCO_3$, $BaCO_3$, and $MgCO_3$), all of which are insoluble in water, or nearly so.

There are a number of percarbonates, including the true ones (analogues of the persulphates), the potassium and sodium perdicarbonates being obtained by electrolysis of cold saturated solutions of the normal carbonates, or by the action of carbon dioxide on the peroxides in presence of absolute alcohol, etc. In common with sodium perborate and the persulphates they are used as bleaching and oxidizing agents.

CARBON TETRACHLORIDE (**Tetrachloro-Methane**) (CCl_4)—A thin, colourless, poisonous liquid, of pungent aromatic odour, b.p. 76·75° C., prepared from choloform or carbon disulphide or methane by the action of chlorine. It has a sp. gr. of 1·5835, freezes at $-22·9°$ C., and is largely used as a solvent for fats, in fire extinguishers, as a drug in cases of hook-worm, as a parasiticide, and in making cleansing compounds. Experience has shown that it is dangerous to use carbon tetrachloride fire extinguishers in confined spaces where users cannot avoid breathing the poisonous fumes (containing phosgene) that are produced by its decomposition; moreover, it is not without action on the metal parts of chemical plant, particularly in presence of moisture, owing to the production of hydrochloric acid. (See Solvents.)

CARBON TETRAFLUORIDE (CF_4) (b.p. $-150°$ C) can, it is stated, be obtained in odourless gaseous form by the direct action of fluorine on various forms of carbon and by another method. (See Annual Report, *Chem. Soc.*, 1926, p. 61.)

CARBON TRICHLORIDE (C_2Cl_6) (**Hexachloroethane, Perchloroethane**) is a colourless crystalline compound of camphor-like odour, soluble in alcohol and ether, which melts and sublimes at 185° C. It is prepared by the action of chlorine upon ethyl and ethylene chlorides.

CARBONATES—See Carbon (Carbonic Acid).

CARBONIFEROUS—The oldest or Palæozoic system of geological formation, including the coal measures.

CARBONIZATION—See Coal.

CARBONYL—The group, : C : O. (See Metallic Carbonyls and Nickel (Carbonyl).)

CARBONYL CHLORIDE (**Phosgene**) ($COCl_2$) is formed when a mixture of carbon monoxide and chlorine gases in equal volumes is exposed to sunlight, and was used for "gassing" in the Great War, being a suffocating and extremely poisonous gas. It is produced by passing a rapid current of the mixed gases, at the ordinary temperature, over highly activated wood charcoal, the product being liquefied by use of a freezing mixture. The liquefied carbonyl chloride, of sp. gr. 1·43 at 0° C. and b.p. 8·2° C., immediately assumes the gaseous form upon exposure

CARBONYL CHLORIDE (*Continued*)—
to the air and crystallizes at − 128° C. Petrol, benzol, and ethyl-acetate dissolve an equal weight of the gas, and these solutions are used in the coal-tar colour industry, also for exterminating rats and moles, making synthetic essence of violets and for removing iron oxide from certain glasses so as to increase their refractiveness. An account of its manufacture is given by G. M. Dyson (*Ind. Chem.*, 1925, i., 537).

CARBONYL FERROCYANIDES as found in spent oxide of iron and in "cyanogen mud" products (obtained in the purification of coal gas) can be easily recovered from the crude mother-liquor resulting from the production of potassium and sodium ferrocyanide from these materials, and have been found useful as oxygen carriers in dyeing and printing processes. Sodium carbonyl ferrocyanide has also proved useful as a substitute for prussiate in making aniline blacks (see F. Scholefield, *Chem. and Ind.*, 1929, **48,** 87).

CARBONYL SELENIDE—See Pearson and Robinson, *J.C.S.*, 1932, p. 652.

CARBONYL SULPHIDE—See T. Pearson (with others), *J.C.S.*, 1932, p. 660.

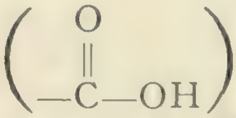
"CARBORAFFIN"—A carbonaceous decolorant black, made by mixing peat with a strong solution of zinc chloride, drying, and heating to 700° F., the zinc being subsequently washed out with dilute hydrochloric acid and water. This is stated by Stanek to have 80 times the decolourizing power of bone char.

"CARBORUNDUM"—See Abrasives.

"CARBOSIL"—A proprietary water-softening material, being a combination of sodium carbonate and silicate, used also as a detergent.

"CARBOXIDE"—An American fumigant, being a mixture of liquefied ethylene oxide and carbon dioxide, particularly advocated for the fumigation of foodstuffs.

CARBOXYL GROUP



$\left(\begin{array}{c}\mathrm{O}\\ \|\\ -\mathrm{C}-\mathrm{OH}\end{array}\right)$—Characteristic of the monobasic fatty and other organic acids, the H of which is replaced in the formation of salts.

CARBOXYLIC ACIDS—The production of certain of these acids (some of which are of use for paper sizing and for the preparation of shellac-like bodies, etc.) by catalytic oxidation of paraffin hydrocarbons is the subject of an article (*C.T.J.*, 1929, **85,** 217).

"CARBROX"—A decolourizing carbon used in sugar-refining.

CARBUNCLE—See Garnet.

CARBURETTED WATER GAS—See Water Gas.

CARBURETTOR—Appliances for supplying the illuminating material to water gas and motor spirit to the internal engines of motor-cars, etc.

"CARBURITE"—A smokeless fuel produced by a special process of carbonizing coal.

CARDAMOMS—The nearly ripe fruit of shrubs (*Elettaria repens, Alpinia cardamomum,* and *Amomum repens*) which grow on the Malabar coast and islands in the Indian Sea, etc.; used as condiments and stimulant aromatics. They yield 4·25 to 5 per cent. of an aromatic essential oil of sp. gr. varying from 0·895 to 0·947 at 15° C., rotation +22° to +46°, and ref. ind. of 1·460 to 1·4673 at 20° C., according to the kind, there being several oils on the market, known as Ceylon, Malabar, Siam, etc. Old cardamom oil has been found to deposit crystals of a terpene hydrate ($C_{10}H_{16},3H_2O$). The Ceylon oil is said to contain chiefly terpenes; the Malabar oil contains cineol as its chief constituent; while the Siam oil contains borneol as chief constituent, and all are used in medicine and for flavouring purposes.

CARENE—See Sylvestrene.

CARMINE—See Cochineal.

CARMINIC ACID—See Cochineal.

CARNALLITE—One of the Stassfurt salts ($KCl,MgCl_2,6H_2O$) containing about 0·02 per cent. of rubidium chloride and 0·0002 per cent. of cæsium chloride. (See A. Küpper (*B.C.A.*, 1927, A, 479) and Potassium.)

CARNAUBA WAX (**Brazil Wax**)—See Waxes.

CARNELIANS—See Cornelians.

CARNOTITE—Mineral uranium-potassium vanadate of yellowish colour and variable composition. (See Vanadium, Radium, and Uranium.)

CAROA FIBRE (*Neoglazoria variegata* of Brazil)—Suggested for employment in paper-making and the textile industry.

CAROB—See Locust Kernel.

CARO'S REAGENT—Permonosulphuric acid (H_2SO_5). (See R. H. Vallance, *J.S.C.I.*, xlv., 66 T.)

CARONE ($C_{10}H_{16}O$)—A ring ketone of the terpene series, being a colourless oil; b.p. 210° C., with an odour of peppermint and camphor.

CAROTINOIDS—A term used in respect of carotene, xanthophyll, lycopin, fucoxanthin, and rhodoxanthin, five colouring matters associated with plant life.

Chlorophyll is invariably associated with carotene and xanthophyll. Many of the yellow animal pigments are either true or modified carotinoids. (See J. M. Gulland on "The Chemical Constitution of the Carotenoid Pigments," etc. (*Chem. and Ind.*, 1930, **49**, 839); Chlorophyll, Plant Colouring Matters (p. 711), and Vitamins.)

CARRAGEEN—See Sea-weeds.

CARRON OIL—A mixture of olive oil or cotton-seed oil and lime-water in equal parts, used as an application for burns.

CAROTENE (**Carotin**)—See Caratinoids and Plant Colouring Matters.

CARTHAMUS—See Safflower.

CARVENE—A terpene ($C_{10}H_{16}$) contained in oil of cumin.

CARVONE (**Carvol, Carvocrol**)—The principal constituent of oil of caraway seeds; a colourless, liquid ketonic body ($C_{10}H_{14}O$) isomeric with thymol, used as an anthelmintic in hook-worm diseases; sp. gr. 0·981, and b.p. 236° C. (See A. Wagner, *B.C.A.*, 1929, B, 111, and Caraway Oil.)

CASCARA SAGRADA (**Persian Bark**)—The dried bark of *Rhamnus purshianus*, a kind of buckthorn, a genus of Rhamnaceæ; a native of British Columbia and several of the U.S.A.; used as a laxative, etc. It contains some oil, of which certain particulars are given by A. Jermstad (*B.C.A.*, 1930, B, 740).

CASCARILLA BARK—The dried bark of shrubs (*Croton eleutheria* and *Croton cascarilla*) indigenous in the West Indies and Bahama Islands. In addition to other extractives, it yields from ½ to 1·75 per cent. of a volatile aromatic oil and a crystalline body named cascarillin. The bark infusion is used medicinally as a cathartic, stomachic, tonic, and expectorant.

CASE-HARDENING STEEL—See references to Iron, p. 499.

CASEIN, the nitrogenous constituent of the milk of mammalia, is a member of the group of proteins, somewhat allied to legumin or vegetable casein, and has colloidal properties. Cow's skimmed milk is the principal source of the commercial article, and contains from 2·5 to 4·2 per cent. The curdling is generally effected by the addition of very dilute hydrochloric, sulphuric, or acetic acid, or rennet, and the curd thus produced and sometimes further purified is washed and dried. The yield of casein by the natural souring method resulting from the production of lactic acid is usually less than that of the other methods. The English casein, as prepared by precipitation with acid, is also known as "caseinogen."

Soya beans constitute another valuable source, the casein being extracted from the beans when freed from oil, by digestion with a 5 per cent. solution of sodium carbonate, followed by precipitation with a 5 per cent. solution of hydrochloric acid.

Casein is white to yellowish in colour, insoluble in water, but soluble in alkaline solutions, the soluble form as sold being casein, to which some proportion of sodium borate (about 10 per cent.) or sodium carbonate (about 20 per cent.) has been added.

It finds commercial applications in the sizing and dressing of cotton, as a silk weighting agent, and particularly as a binding material in the compounding of distempers and other water paints capable of giving surfaces little affected by rain. (See Lime Washes.) It is also used in the preparation of foods, plastics, ivory substitutes, insecticides, and for coating paper, etc. Its value as an adhesive is referred to under Adhesives. Considerable quantities are imported from the Argentine.

Its composition may be approximately expressed as follows: carbon, 53·8 per cent.; hydrogen, 7·2 per cent.; nitrogen, 15·6 per cent.; oxygen, 22·5 per cent. and sulphur, 0·9 per cent. K. Linderstromlang (*B.C.A.*, 1929, A, 1093) concludes from his experiments with this substance that it consists of at least three fractions which in their proper proportions constitute the original substance. (See also T. Svedberg (with others), *B.C.A.*, 1930, A, 356.)

Good rennet-made casein is the only sort fit for use in making plastics in imitation of tortoiseshell, jade, lapis luzuli, brush-backs, buttons, etc. It is prepared by moistening with 25 per cent. water, in which it swells, and is then forced into the shape of rods, and subsequently rolled out

CASEIN (*Continued*)—

in sheet form and put in a bath of 10 per cent. formaldehyde, which penetrates and prevents the sheets when dried, from losing the water with which it has been plastified.

Calcium caseinate is used medicinally.

References: Article on the manufacture of casein plastics by W. H. Simmons (*Ind. Chem.*, 1930, vi., 206, 229, and 297); F. P. Nabenhauer on "Manufacture of Casein and Lactose from Skim Milk" (*Ind. Eng. Chem.*, 1930, **22,** 54); Mummery and Bishop on "Solubility Method of Classifying Acid Caseins" (*Analyst*, 1930, **55,** 367); G. M. Moir on "The Chemistry of the Separation of Casein" (*Analyst*, 1931, **56,** 2); Casein and its industrial applications, with special reference to Canada (subject of an official memorandum, for abridgment of which see *Chem. and Ind.*, 1925, **44,** 986 and 1009); articles by C. H. Butcher (*Ind. Chem.*, 1925, i., 250; 1928, iv., 20; *C.T.J.*, 1925, **77,** 365, 505, 533, 562; 1926, **79,** 421); W. L. Davis (*Ind. Chem.*, 1929, v., 202; and book on *Casein*, by E. L. Tague (Constable and Co., Ltd., London); Adhesives, Cheese, Galilith, Milk, and Paints.

CASHEW-NUT OIL—A pale, non-drying yellow oil expressed from the kernels of the fruit of *Anacardium occidentale,* N.O. Terebinthaceæ (widely distributed in tropical regions, including the E. and W. Indies, South America, India, and the Pahang district of the Malay Peninsula); the yield being from 40 to 45 per cent. It requires high pressure for extraction, and the cake remaining after crushing of the oil is rich in albuminoids. The oil is stated to consist mainly of anacardic acid and cardol, and is soluble in alcohol, ether, etc.; sap. v. of about 180, i.v. 60·6; used in medicine; also for colouring oils, fats, etc. The nuts are used for icing almonds. (See Harvey's Brit. Patent, 272,509, and M. C. Harvey (*B.C.A.*, 1929, B, 179).)

CASING-HEAD GAS—See Petroleum.

CASSAVA—The West Indian name of a starch obtained from the roots of the *Manioc* (*Jatropha manihot* L.), growing in the East and West Indies, from which tapioca (as known in this country), laundry starches, and power alcohol are made. Manioc is the Brazilian name for the product of *Manihot utilissima,* cultivated largely in S. America. (See Manioc and Tapioca.)

CASSIA FISTULA (**Purging Cassia**), of the genus Leguminosæ, is a plant or shrub which yields a dye, and the bark of which is used in tanning and medicine; it occurs in Upper Egypt and East India, and is cultivated in the tropical parts of America and Africa.

CASSIA OIL is obtained from the dried bark of the Chinese *Cinnamomum cassia* (*aromaticum*). It yields by distillation with salt water from $\frac{1}{2}$ to 2 per cent. of a volatile oil, nearly identical with cinnamon oil, containing from 75 to 80 per cent. cinnamic aldehyde. Cassia buds from the *Cinnamomum lauresii* yield a somewhat similar oil, which, however, is not so aromatically pleasant. The sp. gr. of the oil is 1·05 to 1·065 at 15° C., rotation $+1°$ to $-1°$, and ref. ind. 1·585 to 1·605 at 20° C. It is soluble in alcohol, ether, etc., is used in perfumery, also for flavour-

CASSIA OIL (*Continued*)—
ing, scenting brown Windsor and other soaps, and as a source of cinnamic alcohol. (See Cinnamon and Cinnamic Alcohol.)

CASSITERITE (SnO_2)—The mineral otherwise known as *Tinstone,* of crystal system, No. 2, and sp. gr. 6·4 to 7·1. It is found in Cornwall, Brittany, U.S.A., and elsewhere. (See Tin.)

CASTANHA OIL (**Brazil-Nut Oil**) is expressed from Brazil nuts, has a sp. gr. 0·918, sap. v. 193·5, and i.v. 106·22. It is pale yellow in colour, melts at 0·4° C., is soluble in ether and carbon disulphide, and used as an illuminant, in soap-making, perfumery, and as a food.

Further details are given by H. A. Schuette (with others) in the *J. Amer. Chem. Soc.*, 1930, **52,** 4114, and 1931, **53,** 2756.

CASTILE SOAP—See Soaps.

CASTOR OIL is a thick, non-drying, yellowish or pale green, odourless oil, extracted or expressed from the seeds of *Ricinus communis,* a plant indigenous in India and cultivated in Brazil, the East and West Indies, Java, Mexico, Panama, Manchuria, and other warm climates. The area under this seed in India is reported as about 1,253,000 acres.

It is a mixture of several glycerides, and upon saponification yields a soap which is perfectly dissolved by water. The splitting of castor oil is the subject of a paper by H. M. Langton. (See *J.S.C.I.*, 1931, **50,** 213 T.) Its chief constituent fatty acid is ricinoleic acid ($C_{18}H_{34}O_3$) (contained in the form of triricinolein), and a recent quantitative examination by Heiduschka and Kirsten (*B.C.A.*, 1930, B, 382) gives the percentage composition of the oil as: rincinoleic acid 82, œlinoleic acid 1·4, oleic acid 6·8, dihydroxystearic acid m.p. (142·5° C.) 1·3, stearic acid 3·4, glyceryl residue (C_3H_5) 4·1, and unsaponifiable matter 0·3 per cent. The seeds of the plant yield from 45 to 55 per cent. oil, averaging 46·4 per cent., the medicinal oil being prepared from seeds which have been husked, while the second and third pressings are used industrially.

The bleaching of castor oil is usually effected by agitation at 200° F. with 2 to 4 per cent. of fuller's earth, followed by agitation with from 0·2 to 1·5 per cent. of prepared decolourizing carbon.

The pressed cake is unfitted for cattle food, as it contains a poisonous body named "ricine," derived from the husks of the seeds. It is a good adhesive material for making plastics, and can be used, it is stated, in compounding tiles and bricks for interior building purposes.

Castor oil has a sp. gr. of 0·969, acet. v. about 150, sap. v. 183 to 186, ref. ind. 1·480 at 15° C., i.v. of 82 to 86, solidifies at $-10°$ to $-18°$ C., and is soluble in alcohol, ether, and benzene, but only slightly soluble in petroleum-ether. The British Pharmacopœia, 1914, restricts the free fatty acids in castor oil to a quantity not exceeding an acid value of 4, and it is to be noted that this content increases with ageing. Its sodium salts are transparent.

It is used in medicine and the lower qualities for soap-making, leather-dressing, as lubricants, in the preparation of Turkey-red oil, and in the manufacture of artificial leather, linoleum, and rubber substitutes.

CASTOR OIL (*Continued*)—

From it, also, several aldehydes can be prepared which are of strong odour and used in perfumery. Completely hydrogenated castor oil melts at 86° C., and has an iodine value 2. (See also Ricine, Ricinoleic Acid, and Turkey-red Oil.)

CATALASE—See Aspergillus and Enzymes.

CATALYSIS—The term "catalytic" is given to a property exhibited by substances in initiating or accelerating and exhilarating chemical action between two or more other substances. For example, platinum in a spongy condition promotes the combination of hydrogen and oxygen gases to form water; a little, when thrown into a mixture of the two gases, causing them to combine with a loud explosion. Platinum black also causes the ignition of coal gas in presence of air, and there is an automatic gas-lighter based on the use of this substance.

The primary alcohols are resolved into aldehydes and hydrogen by passing their vapours through tubes containing certain metals or their oxides; for example, ethyl alcohol gives an 80 per cent. yield when passed over zinc at 660° C., and many organic compounds can be reduced by mixing them with hydrogen and passage over platinum black at a moderate temperature. Electrolytic copper does not exercise any catalytic effect on the oxidation of ethyl alcohol, but when prepared by reduction of the oxide it catalyses the action with the formation of acetaldehyde or acetone.

The Deacon process of manufacturing chlorine is catalytic in character, so also is that of fuming sulphuric acid, the synthetic production of ammonia, the hydrogenation of oils, and the Twitchell process of fat splitting.

Many finely divided substances are capable of exercising catalytic effects; pure precipitated silica, after moderate calcination, effects the decomposition of ethyl alcohol at 280° C., producing ethylene. Pulverized quartz and alumina are capable of serving as catalysts, and it has been shown that titanium oxide (TiO_2) at a temperature of 290° to 300° C. effects the esterification of the vapours of acids and alcohols. Oxides of metals of the fifth and sixth groups of the periodic classification are excellent catalysts, and in particular vanadium oxide. In addition to platinum and copper, iron, nickel, cobalt, palladium, osmium, iridium, ruthenium, and rhodium are all employed as catalysts in certain processes, including the reduction of liquid compounds.

It is important in all catalytic processes to offer as large an extent of surface of the catalysts as possible, and for this purpose solid surfaces are sometimes abraded and sometimes electrolytically deposited on a suitable support. The catalyst is often used in suspension in liquids, being removed at the completion of the operation by filtration or otherwise.

There are substances which act as anti-catalysts, and others as "poisons" to the catalysts, and, of course, it is important that these should be absent in all such operations. The confinement of poisoning to solid catalysts has led to the view that the catalytic surface is so affected as to prevent free access of the reactive agent, the inhibitive agent being absorbed so tenaciously that free evaporation of the

CATALYSIS (*Continued*)—

absorbed molecules and their free replacement by molecules of the reacting system does not take place.

It has been demonstrated that the surfaces of catalysts such as those of charcoal or sugar are not uniform, and that enough poison to cover 0·3 per cent. of the surface may stop the autoxidation of charcoal.

Experiments by E. K. Rideal have shown that by adding iron to sugar the activity of the surface is increased 14 times, and by the addition of nitrogen as well as iron the surface activity is increased some 800 times. Inhibitors for slowing down some processes are sometimes useful as contrasted with the action of promoters—as, for example in respect of paints and varnishes for export to hot climates. (See *Chem. and Ind.*, 1926, **45**, 779; E. F. Armstrong and T. P. Hilditch on "Catalysis at Solid Surfaces" (*Chem. and Ind.*, 1925, **44**, 701); *J. Physical Chemistry*, 1929, **33**, 1441; and report on a discussion of problems concerning surface catalysis (*C.T.J.*, 1925, **77**, 303).)

Moureau and Dufraisse interpret the so-called poisoning of oxidizing catalysts by a theory of "antioxygenes," which act by catalytically decomposing the particular peroxide which results from the union of the autoxidizable substance with one molecule of free oxygen. The said peroxide, by oxidizing the antioxygene forming its peroxide, thus becomes reduced to another form of peroxide, with the result that the two peroxides mutually destroy each other and regenerate the original bodies. (See *J.C.S.*, 1925, cxxvii., 1; and E. B. Maxted on "The Poisoning of Catalysts," *Ind. Chem.*, 1925, i., 449.)

The catalyst is often unimpaired at the end of its action, although that is probably dependent upon the formation of intermediate compounds. In some cases it would appear that occlusion or adsorption (not capillary, but specifically chemical in essence) of one or more of the interacting substances occurs at the surface of the catalyst, thus securing greater concentration.

The rate of combination of a (moist) theoretical mixture of carbon monoxide and oxygen ($2CO + O_2$) in contact with a gold surface in a "normal" active state at 300° C. is, according to Bone and Andrew, always proportional to its pressure.

Different catalytic agents activate susceptible molecules in various ways; for instance, whilst alcohol yields ethylene and water by the action of alumina or kaolin, it yields acetaldehyde and hydrogen by the action of pulverulent nickel.

An application of catalysis advocated by Dr. Sokal, of New York, is in respect of internal combustion engines. The interior of the cylinder head or firing chamber, when painted with a certain refractory composition containing a catalyst, promotes, it is stated, the explosion, and gives an increase in power, the combustion being more complete.

Catalysis may be viewed as due generally to the action of energized (activated) forms of chemical entities, resembling the action of enzymes, or the catalytic agents may act as third systems and participate in the chemical changes concerned. For example, the reaction-mechanism in the sulphuric acid contact process would appear to depend upon the

CATALYSIS (*Continued*)—

alternate reduction of ferric oxide when that agent is used as the catalyst and oxidation of the reduction product, the series of reactions being represented as shown by B. Neumann (*B.C.A.*, 1929, B, 205). The physical change often observed in the catalytic agent would of itself appear to indicate chemical participation in the process.

The crystallization of a saturated solution can be quickened by addition of an already formed crystal of the same compound, and this is illustrative of a number of allied changes.

Catalysts which participate in the changes involved in the fixation of nitrogen are referred to under that heading. Sulphuric acid, certain metallic chlorides, and some alkaline sulphides are used as catalysts in the production of intermediates, and bog-iron ochre can be used as a catalyst in the production of oils from coal and tar.

Catalytic changes are in many cases induced or influenced by the use of high pressure, and temperature is, of course, a matter of importance. (See Report of Discussion on Catalytic Reactions at High Pressures (*Proc. Roy. Soc.*, 1930, A, **127**, 240, or *B.C.A.*, 1930, A, 867); papers by E. B. Maxted and E. K. Rideal, with report of discussion thereon (*Chem. and Ind.*, 1931, **50**, 149-155); J. E. Nyrop on the "Catalytic Action of Surfaces" (*Chem. and Ind.*, 1931, **50**, 752); T. P. Hilditch on the fourth report of the committee of the American National Research Council on contact catalysis (*Chem. and Ind.*, 1926, **45**, 447); "Theories of Catalysis," by S. K. Tweedy (*Chem. and Ind.*, 1926, **45**, 157 and 177); "Catalytic Oxidation of Organic Compounds in the Vapour Phase," by C. R. Downs (*J.S.C.I.*, 1926, **45**, 188 T); "The Inversion of Reactions in Catalysis," by Paul Sabatier (*Chem. and Ind.*, 1927, **46**, 681 and 702); "Sintering of Active Copper Catalysts," by F. H. Constable (*J.C.S.*, 1927, p. 1578); "Catalysts and their Industrial Applications," by H. Seymour (*Ind. Chem.*, 1926, ii., 226); "The Negative Catalysis of Auto-oxidation," by Moureau and Dufraisse (*Chem. and Ind.*, 1928, **47**, 819 and 848); and books by E. Jobling (J. and A. Churchill) and E. K. Rideal and H. S. Taylor on *Catalysis in Theory and Practice* (Macmillan and Co., Ltd., London); S. J. Green on *Industrial Catalysis* (Ernest Benn, Ltd., London); and T. P. Hilditch on *Catalytic Processes in Applied Chemistry* (Chapman and Hall, Ltd., London); Adsorption (under Colloid Chemistry), Chemical Interaction, Enzymes, Pressure (High), and Vitamins.)

CATAPHORESIS—See Osmosis.

CATECHOL (**Ortho-dioxybenzene**) ($C_6H_4(OH)_2$), formerly known as pyrocatechin and pyrocatechol, is a monohydic phenol of m.p. 104° C. and b.p. 245° C. found in raw beet sugar and the leaves of the Virginia creeper. It can be obtained by the distillation of catechin (cutch) and from certain resins or *o*-phenol-sulphonic acid by fusion with potash, but is usually prepared from guaicol by heating with hydriodic acid. It is crystalline, sublimable, and soluble in water, alcohol, and ether. It possesses antiseptic properties, is used in photography, and there is a method for recovering it from the effluent ammonia liquors of coke ovens. Vanillin can be derived from it. (See D. W. Parkes, *J.S.C.I.*,

CATECHOL (*Continued*)—
1927, **46,** 186 T; *Chem. and Ind.*, 1929, **48,** 218; *J.S.C.I.*, 1929, **48,** 81 T, and M. Nierenstein (*B.C.A.*, 1930, A, 1223.)

CATECHU (**Cutch**)—An astringent extract, rich in tannin (25 to 50 per cent.), prepared from the leaves, wood, and pods of the *Mimosa catechu* and other species of acacia and catechu plants grown in Bombay, Bengal, Nubia, and elsewhere, also from the bark of the mangrove tree, by digesting the various parts of the plants in water and evaporation of the solution. Apart from its use in tanning, it is used in dyeing cotton a fast brown, and when treated with nitric acid it yields a bright yellow powder possessing dyeing characters like those of picric acid.

Catechu contains so-called catechins (which are nearly related to certain anthocyans, flavones, etc.), one of which is stated to be a crystalline principle of the formula ($C_{15}H_{14}O_{6}4H_{2}O$) readily soluble in hot water and in alcohol, and it is from the catechins content that the tannins are produced through oxidation. The catechin from *Acacia catechu* is known as acacatechin, of which the synthesis has been accomplished. There are a number of varieties, including gambia catechu (*Catechu pallidum*), a pale sort; betel-nut catechu; cutch (*Areca catechu*); and Nubian catechu from Egyptian acacias. (See F. A. Mason on "The Catechin Problem" (*J.S.C.I.*, 1928, **47,** 269 T); also Gambier and Tannins.)

CATHARTIN—See Senna.

CATHIONS (**Cations**)—See Electricity.

CATHODE—The negative pole of a battery. (See Electricity.)

CATHODE RAYS—See Radio-activity.

CAT'S EYE—A quartz (SiO_2) of translucent appearance found in Ceylon.

CATTLE FOODS—See Feeding Stuffs.

CAUSTIC POTASH—Potassium hydroxide. (See Potassium Compounds.)

CAUSTIC SODA—Sodium hydroxide. (See Sodium Compounds.)

"CAY-CAY BUTTER"—See Dika Butter.

CAYENNE—See Capsicum.

CEDAR-LEAF OIL, from *Juniperus virginiana,* contains limonene, cadinene, borneol, etc.; has a sp. gr. of 0·883 to 0·888 at 15° C., opt. rot. $+55°$ to $+65°$ at 20° C., and is soluble in alcohol and ether. The commercial oil is stated to be often derived from *Thuja occidentalis.*

The oil of *Librocedrus bidwillii* of New Zealand, extracted from the leaves, has been shown to consist of terpenes 30 per cent. (*d*-pinene being the chief one) and 70 per cent. sesquiterpenes.

CEDAR-WOOD OIL—A pale yellow essential oil of agreeable odour, used in perfumery and as an insectifuge, distilled from the wood of the *Juniperus virginiana, J. procera*, etc., to the extent of about 16 ozs. per cwt. Sp. gr., about 0·940 to 0·960 at 15° C.; opt.rot., $-25°$ to $-45°$; ref. ind., 1·495 to 1·510 at 20° C. It is soluble in alcohol and ether, and contains as the chief constituent a crystalline substance named cedar-camphor together with the sesquiterpene cedrene ($C_{15}H_{24}$). (See Ruzicka and Van Melsen (*B.C.A.*, 1929, A, 932), and Blumann and Schulz (*B.C.A.*, 1931, A, 1068).)

CEDRENE—See Cedar-Wood Oil and Hydrocarbons (Terpenes).

"CELANESE"—The trade-mark name of certain cellulose acetate silk goods. (See Silk Substitutes.)

CELERY OIL—Distilled from the fruit of *Apium graveolens*, having a sp. gr. of from 0·87 to 0·895. The yield is 0·2 per cent.; it has the odour and taste of celery, is soluble in alcohol, ether, etc., contains from 2 to 3 per cent. of a substance named lactone sedanolide ($C_{12}H_{18}O_2$), (to which it owes its odour), associated with other substances, and is used for flavouring purposes.

CELESTINE (Celestite)—Native strontium sulphate ($SrSO_4$), of crystal system, No. 4, and sp. gr. 3·9; it takes its name from its colour, and fine specimens are found in Sicily. (See Strontium.)

"CELITE"—Preparations used as filter-aids, including "super-cel."

"CELL CONCRETE"—A material used for heat insulation, of sp. gr. 0·25 to 0·9, and hard as concrete, consisting of sand and cement mixed with a froth liquid.

"CELLITE"—The name of products prepared from a large deposit of hydrated amorphous silica on the Pacific coast in California, consisting of the skeletons of marine diatoms, useful for making insulating furnace linings and bricks. (See Kieselgühr.)

CELL LIFE—See *Cytology*, by J. Gray (Cambridge University Press).

"CELLOPHANE"—A transparent viscose paper used for wrapping, etc.

"CELLOSOLVE"—The mono-ethyl ether of glycol. A cellulose solvent for use in the manufacture of varnishes and lacquers. (See T. H. Fairbrother (*Ind. Chem.*, 1928, iv., 179).)

CELLULOID (Xylonite)—In the preparation of this material, cellulose (usually in the form of paper) is nitrated with a mixture of sulphuric and nitric acids until the nitrogen content amounts to about 10 to 11 per cent., and after bleaching, washing, and drying, it is gelatinized with a mixture of synthetic or natural camphor dissolved in alcohol, at which stage any colouring matters may be introduced as desired. It is then manipulated on hot rollers, and pressed into blocks or other forms. The optimum camphor content of celluloid is about 20 per cent., and various substances are introduced in addition to act as stabilizing and plasticizing agents. It is a plastic material at 75° C., and after evaporation of the solvent and upon cooling can be turned on a lathe. Celluloid is soluble in acetone, amyl acetate, hexaline acetate, and isobutyl acetate. It is largely used for making combs, brush and knife handles, piano-keys, billiard balls, collars, cycle pumps, mudguards, toys, etc. The celluloid used in making cinematograph films is of a more highly nitrated character, while the proportion of camphor incorporated is smaller, but it is much more inflammable in character.

Celluloid is easily inflammable, and only becomes plastic at a temperature not far below that at which it decomposes. To overcome these objections, and its not too pleasant odour, many modifications of composition have been used in which the camphor is substituted by other substances, such as triphenyl and tritolyl phosphates, triacetin,

CELLULOID (*Continued*)—

etc., with more or less success. (See article by O. C. Ellington on the "Storage Properties of Transparent Celluloid" (*J.S.C.I.*, 1929, 267 T); Cellulose, Dopes, Explosives (Gun Cotton), and Pyroxylin.)

CELLULOSE $(C_6H_{10}O_5)_n$—The structural and preponderating tissue forming the walls or skeletons of plants, convertible into sugar, and extensively employed in the manufacture of paper, gun-cotton, nitrocellulose, collodion, lacquers, and silk substitutes; also in compounding celluloid articles, and the preparation of celluloid films, some of which have a basis of cellulose acetate dissolved in acetone, or cellulose dissolved in amyl acetate or amyl alcohol. (See Dopes, Explosives, and Pyroxylin.)

Cotton contains about 90 per cent. cellulose, and the proportion in woods of various sorts ranges from about 40 to 60 per cent. (See Paper.)

According to the micelle theory, cellulose is based upon glucose residues aggregated into chains of from 50 to 100 units, some 30 to 50 of these chains being further united, forming complex bundles or micelles. (See C. J. J. Fox, *J.S.C.I.*, 1930, **49,** 83 T.)

The investigations of Bragg and his associated workers using X-ray methods would make it appear that cellulose is composed to a great extent of a mass of crystals and that in each crystal there is a periodicity parallel to the direction of the fibre, thus supporting the chemical evidence of a long chain of many links and suggesting the possible synthesis of sugars and the condensation of sugars into cellulose.

The several varieties of cellulose are substantially identical in cuprammonium solution with normal cotton cellulose, and from the optical, active, and mass action relationships it reacts on its simplest chemical structural form, $C_6H_{10}O_5$ (K. Hess).

When heated to 260° to 270° C. in a paraffin bath it begins to decompose, but in common with wood and starch it can be distilled completely, according to H. E. Fierz-David, when admixed with sufficient nickel oxide and heated in hydrogen under a pressure of 100 to 250 atmospheres. (Compare Berginization.)

Cellulose is stated to dissolve in sulphuric acid at concentrations between H_2SO_4,H_2O and $H_2SO_4,3H_2O$ at ordinary temperatures without charing, and from a colloidal solution in 62 per cent. H_2SO_4 it can be precipitated by dilution with water, alcohol, ether, or electrolytes.

By the action of sodium hydroxide on cellulose, an additive compound (alkali cellulose, $C_6H_9O_4.ONa$) is said to be formed. The absorption of sodium hydroxide from aqueous solution (2 to 8 per cent.) by cotton occurs rapidly, and the maximum effect is produced by concentrations of 20 per cent. and over. In 4 to 5 per cent. solutions the compounds $12C_6H_{10}O_5,NaHO$ and $6C_6H_{10}O_5,NaHO$ are said to be formed from native and mercerized cotton respectively (J. S. Rumbold, *J.Amer.C.S.*, 1930, **52,** 1013); see also S. M. Neale on "The Action of Caustic Soda on Cellulose" (*J.S.C.I.*, 1931, **50,** 177 T).

Cellulose on complete hydrolysis with dilute sulphuric acid yields the theoretical quantity of glucose, and all forms of cellulose, it is alleged, yield the same trimethyl cellulose when completely methylated. Irvine

CELLULOSE (*Continued*)—

thinks that the bulk of evidence points to the view that cellulose is built up of three glucose molecules joined together by polymerization. (See W. N. Haworth (with others), *J.C.S.*, 1931, p. 824.)

It is accompanied in vegetable matters with other nearly associated substances—viz., vasculose or ligno-cellulose, pectose or pecto-cellulose, and cutose, all of which are attacked by various chemical reagents to which cellulose is indifferent. Various methods used for preparing cellulose according to the applications to be made of the product, including treatment of the vegetable matter with (1) caustic soda (2) bisulphites, and (3) oxidizing agents followed by alkalies, are described under the heading of Paper. (See J. Macdonald, *J.S.C.I.*, 1927, **46**, 251 T.)

Respecting the oxidation of cellulose see H. Hibbert and J. L. Parsons (*J.S.C.I.*, 1925, **44**, 474 T).

Cross and Engelstad have described the action of aqueous sulphurous acid on ligno-cellulose and the auxiliary contribution of ammonia in effecting a complete resolution into cellulose of good character (*J.S.C.I.*, 1924, **43**, 253 T; and 1925, 267 T).

To prepare pure cellulose, Cross and Bevan boil the raw material with a 1 to 2 per cent. solution of caustic soda, and, after washing, expose the undissolved portion to gaseous chlorine, and again boil the product with dilute alkali, thus eliminating all the non-cellulosic constituents (hemicelluloses, pectic compounds, lignone, and cutose), and yielding pure white cellulose.

Gaseous, liquid, and watery solutions of chlorine are all used in various methods of preparing cellulose from its different sources. In one such method, jute is first of all boiled in a 1 per cent. solution of caustic soda, then washed and pressed until it contains about its own weight of water, after which it is exposed to moist chlorine gas for an hour, and again washed to rid it of the resulting hydrochloric acid. This is followed by washing in a boiling solution of 1 to 2 per cent. sodium sulphite, and the cellulose is separated by rendering the solution alkaline with a 0·21 per cent. solution of sodium hydroxide and keeping the mixture at the boil for two or three minutes.

The yellow chlorinated derivative is said to have the composition $C_9H_{18}O_9Cl_4$ and the yield 75 to 80 per cent. This is described as a mixture of alpha-cellulose (resembling normal cotton cellulose) and beta-cellulose, less resistant to the hydrolysing action of acids and alkalies.

In other processes for preparing cellulose from ligno-cellulose, such as jute, this beta variety is hydrolysed and dissolved, causing a fall in the yield to from 62 to 66 per cent.; one of these processes is based upon the action of nitric acid and chlorine, and another on that of dilute nitric acid at 60° to 80° C. (See U. Pumilio, *C.T.J.*, 1921, **69**, 521, and 1924, **75**, 98.)

Cellulose is soluble in an ammoniacal solution of cupric oxide, and this solution readily dissolves cotton and linen fibres; advantage being taken of this solubility in the manufacture of "Willesden paper," which is prepared by moistening the surface of a coarse paper with this solution after the surface has been gelatinized.

CELLULOSE (*Continued*)—

The etherification of cellulose can be effected, using alkali and alkyl bromides or iodides, by heating in a closed vessel for several hours, and the products are likely to become of increasing interest for making photographic film-stock.

Celluloses used for industrial purposes are of three classes—viz., the so-called pecto-celluloses, such as cotton, ramie, flax, and hemp; the ligno-eclluloses, such as jute and the various woods; and, lastly, cereal straws and grasses. Ramie and hemp contain about from 63 to 66 per cent. cellulose.

For the production of sugar and alcohol from cellulose see the articles Alcohol, Sugar, and Glucose, and the Report for 1925 of the Fuel Research Board (H.M. Stationery Office).

Cellulose from purified cotton linters prepared by the viscose process has proved a good substitute for the usual sausage skins derived from animal intestines. (See Henderson and Dietrich, *Analyst*, 1927, **52,** 37.) Modifications of cellulose are largely used, amongst other applications, in the making of food containers and wrappers.

The nitration of cellulose is referred to under the headings of Collodion, Cotton, Explosives, Nitro-cellulose, and Pyroxylin.

Other references: "Cellulose Derivatives," etc., by Cross, Bevan, and Beadle (*J.S.C.I.*, 1893, p. 498); *C.T.J.*, October 19, 1923, and 1927, **80,** 51; papers by J. W. Bain (*J.S.C.I.*, 1927, **46,** 193 T); C. Fox and L. Hall (*J.S.C.I.*, 1927, **46,** 281 T); J. S. Remington (*Ind. Chem.*, 1926, ii., 402); "Cellulose," by C. F. Cross (Inst. of Chem. Lecture). The effluent water of cellulose manufacture, by Heiduschka and Munds (*B.C.A.*, 1929, B, 125); the utilization of sulphite cellulose liquor (*C.T.J.*, 1930, **87,** 275); "Swelling and Acetylation of Cellulose," by Bernoulli (with others) (*B.C.A.*, 1930, A, 1168); "The Micelle Chemistry of Cellulose," by C. J. J. Fox (*J.S.C.I.*, 1930, **49,** 83 T); "Some Aspects of the Chemistry of Cellulose and other Polysaccharides," by Karl Freudenberg (*J.S.C.I.*, 1931, **50,** 287 T); "Cellulose—the Rival of Coal Tar as a Raw Material," by A. J. Hall (*Ind. Chem.*, 1931, vii., 355, 397, and 508); "The Adsorption Power of Cellulose," by S. R. H. Edge (*J.S.C.I.*, 1929, **48,** 118 T); "Films and Fibres derived from Cellulose," by H. Levinstein (*J.S.C.I.*, 1930, **49,** 55 T and 77 T); the Chemical Characteristics of different Celluloses, by Fotjew and Jakimanskij (*B.C.A.*, 1930, B, 96); "Chemistry of Cellulose with special reference to Rayon," by A. W. Schorger (*J.S.C.I.*, 1930, **49,** 154 T); K. Hess (with others) (*B.C.A.*, 1927, A, 44, 753, 861, and 1058; and 1928, A, 48); *Researches on Cellulose*, by Cross and Dorée (Longmans and Co.); *Technology of Cellulose Esters*, by E. C. Worden (Spon and Co.); *Chemistry of Cellulose and Wood*, by A. W. Schorger (McGraw, Hill and Co.).

See also Dopes, Films, Glucose, Lacquers, Lichenin, Lignin, Paper, Plasticizers, Silk Substitutes, "Talloel," and Wood.

CELLULOSE ACETATE (**Sericose**) is a yellowish, non-inflammable substance prepared by the acetylization of cellulose in varying degrees.

CELLULOSE ACETATE (*Continued*)—

It is soluble in acetone and some other solvents in different degrees, and is used in making cinematograph films, dopes, and silk substitutes. The action of acetic anhydride in the presence of sulphuric acid upon cellulose leads to the production of a number of distinct bodies, which are described in an article by W. Weltzein and R. Surger (*J.S.C.I., Abs.*, xliv, B, 440). The tri-acetate is the most important constituent product. The processes are carried out by the action of acetic acid and its anhydride on the dry cellulose in presence of a dehydrating agent such as sulphuric acid, zinc chloride, or phosphoric acid.

Applied as dope to wire netting, it is used as a substitute for glass under the name of "Spondite"; it is also largely used in making lacquers, construction of storage batteries, and in sheet form under the name of "Cellon." With respect to dyeing of cellulose acetate and silk substitutes, see Silk Substitutes (p. 843). (See M. Deschiens (*C.T.J.*, 1927, **80**, 141); H. T. S. Britton (*Ind. Chem.*, 1927, iii., 59 and 116); H. R. S. Clotworthy on "Acetic Acid Recovery in the Cellulose Acetate Industry" (*Ind. Chem.*, 1931, viii., 111); H. Messer on "Softeners for Cellulose Acetate" (*J.S.C.I.*, 1931, **50**, 386 T); Lacquers, Silk Substitutes, and S.R.A. Colours.)

"CELLUTYL" COLOURS—Dyestuffs for cellulose acetate silk.

"CELOTEX"—An artificial building board, made from Bagasse. (See Sugar, p. 867.)

"CELTA"—A French warm and soft variety of silk substitute.

CELTIUM—See Hafnium.

CEMENT (**Portland Cement**) is prepared by the wet process from a mixture of alluvial clay (shales sometimes replacing the clay) and precipitated calcium carbonate or chalk (using about 76 to 78 per cent. of the latter), ground together in water. After allowing the mixture to settle, the water is poured off, the deposit is calcined in rotary kilns of great length, and then ground dry ready for use. It contains tricalcium silicate, dicalcium silicate, and tricalcium aluminate with uncombined lime; has a sp. gr. of 3·17, and on average contains about 22 per cent. silica (SiO_2), 62 per cent. lime (CaO), and 7·5 per cent. alumina (Al_2O_3), also small amounts of potash, soda, and magnesia in the form of free salts. On the Medway (the original home of Portland cement), the river mud can be used in the place of clay.

When mixed with a small proportion of water, it forms a hard, tenacious mass which expands as it solidifies ("sets"), and—unlike ordinary mortar—can be used for hydraulic purposes, the setting being accelerated by rise in temperature. Gypsum can be used instead of chalk, and the sulphurous gases thus produced utilized in making sulphuric acid.

Storage of cement prolongs the time of initial and final setting, and rapid hardening depends largely upon the fineness of division of the constituent materials employed.

In the dry process, as described by C. G. Carter, limestone crushed to pass a 20-mesh sieve and thoroughly dried is mixed with dried clay

CEMENT (*Continued*)—

in the required proportions and clinkered at 2,600° F. The mix contains some 42 per cent. lime, and at this temperature the lime combines with the silica, iron, and alumina. The product is preserved in this form until required and then mixed with 4 per cent. gypsum to lengthen the setting time of the cement, ground in comminuters and tube mills, thus furnishing the finished cement. (See *Chem. and Ind.*, 1930, **49,** 11.)

As to the rotary kiln in cement manufacture, see W. Gilbert (*B.C.A.*, 1931, **50,** B, 22) and Hashimoto and Akiyama (*B.C.A.*, 1931, B, 720).

The partial use of blast-furnace slag in the manufacture of cement is now largely practised in the North of England and Scotland, where suitable clays or marls are rare, and is said to give additional strength. Wennerstrom's method consists in heating the slag with lime in a graphite-lined circular furnace, while R. Grün first of all converts the slag into a basic compound by adding alumina to the charge either before or with the lime, thus reducing the melting-point of the mixture and enabling it to take up more lime. The product, when finely ground with clinker, is stated to make a good cement.

According to Desch, the setting of wetted cements results from the decomposition of the aluminates into colloidal alumina and of the tricalcium silicate into the monocalcium silicate and calcium hydroxide, which slowly crystallizes in a colloidal matrix. In course of time the hydroxide is converted by the absorption of carbon dioxide from the air into carbonate, thus increasing the hardness of the product and its tensile and compression strength; also that of concrete made from it.

The setting time of cement does not change of itself even after prolonged storage out of contact with air, while the time of "set" appears to depend upon the proportion of combined water present in hydrated calcium aluminate or silicate forming a protective sheath round the cement particles, thus resisting or delaying the penetration of water to the active core.

The lime which is set free during the setting of Portland cement, like the slaked lime of ordinary mortar, is capable of entering into combination with silica when presented to it in a sufficiently active form, and good cement can therefore be improved by the addition of a suitable pozzolanic substance. This circumstance also explains why the rapid hardening and maturing of newly made concrete is effected by the application of a dilute solution of sodium silicate. Pozzolanic materials are of volcanic origin, but others are used as substitutes (such as trass, granulated slag, baked slag, and spent shale), and are suitable so long as they contain silica and alumina in active form.

According to S. Yamane (*B.C.A.*, 1929, B, 173) the strengthening process which takes place in Portland cement is due to the reaction: $3CaO,SiO_2 + H_2O \longrightarrow CaO,SiO_2mH_2O + Ca(OH)_2$, and the concentration of hydrated silicate may be taken as a measure of the strength of a given sample of cement.

The limits allowed by the British standard specification for Portland cement are:

CEMENT (*Continued*)—

1. The insoluble residue, as determined by a specified test, must not exceed 1·5 per cent.
2. The contained magnesia must not exceed 4 per cent.
3. The total sulphur content must not exceed 2·75 per cent.
4. The permissible residue on an 180 by 180 sieve is 10 per cent.
5. The loss on ignition must not exceed 3 per cent.
6. The "hydraulic modulus"—that is, the proportion of lime to silica and alumina, as calculated in chemical equivalents by the formula

$$\frac{CaO}{SiO_2 + Al_2O_3}$$

—must not be less than 2 per cent. nor more than 2·85 per cent.

The only single substance so far found to constitute a perfect cement of itself is represented by the formula $3CaO.SiO_2$, but the temperature required to make it, is too high to be commercially available to advantage; admixture of alumina brings down the required temperature to some extent, but even with a mixture of the three oxides in the simple proportions, CaO,Al_2O_3,SiO_2, the lowest temperature required is 1,335° C.

The "Ferrocrete" brand of cement is of rapidly hardening quality, the strength of which at twenty-four hours is stated to be beyond that required by the British standard specification at an age of seven days, whilst concrete made with it is alleged to be stronger at four days than one made with ordinary Portland cement at an age of twenty-eight days. It is of great breaking-load resistance and used in road-making and general construction work. The "Snowcrete" brand is a white variety, valued for use with reconstructed or artificial stone.

It is ordinarily understood that, to resist sea-water action, the alumina content should be kept low, but the French make known as "Ciment Fondu," which fuses at about 1,400° C., and contains a large proportion of alumina, is stated to exhibit remarkable resistance to the decomposing influence of sea-water.

Its composition (1), as given by H. F. Knight, and that of Portland cement (2) in France are given side by side:

	(1) Per Cent.	(2) Per Cent.
Insoluble	0·92	—
Silica	9·76	23·0
Alumina	44·32	7·0
Ferrous oxide	0·47	—
Metallic iron	3·43	4·0
Lime	40·26	64·0
Magnesia	0·57	—
Sulphur (as sulphide)	0·11	—
Alkalies, loss, etc.	0·16	—
Other constituents	—	2·0
	100·00	100·0

CEMENT (*Continued*)—

"Ciment Fondu" has a sp. gr. of 3·049 and a lime ratio or hydraulic modulus

$$\frac{CaO}{SiO_2 + Al_2O_3} = 1{\cdot}21,$$

the figures approximating to the formula, $2Al_2SiO_5, 6Ca_3Al_2O_6, 3CaAl_2O_4$. It exhibits great tensile strength, rapid hardening, indifference to temperature as to setting, and makes concrete much superior to Portland cement concrete, capable of phenomenal loading quality, and immune to the attacks of sea-water and sulphur-impregnated water, etc.

"Ciment Kestner" is a particular cement made from 1 part "Ciment Fondu" and 2 parts of calcined and powdered bauxite, which softens at 1,350° to 1,400°, and melts at about 1,600° C. (See J. Arnould, *B.C.A.*, 1926, B, 363.)

Calcium aluminate cements are manufactured by fusing bauxite and lime together in an electric furnace, and while the amount of lime in all Portland cements ranges from 1·7 to 2·2 times the sum of the silica, alumina, and ferric oxide, the ratio in the aluminate varieties is about 0·66. Again, the silico-alumina ratio in Portland cements is always over 2·5, while in the aluminate qualities the relationship is about 0·25. The cost of these new varieties is relatively high, but improvements in the rotary kiln used for the ordinary cement may be expected to largely overcome the difference in cost of the two varieties.

Works for the production of this class of cement by the employment of blast furnaces have been established at West Thurrock, Essex, the material made from limestone and bauxite being smelted, poured into moulds, and the pigs subsequently ground into fine powder.

The so-called "Titan" cements are quick-hardening and of high strength, having a lime base like Portland and alumina cements, but with titania (TiO_2) as their chief acid constituent in place of silica or alumina. They are made by fusing a mixture of titaniferous iron ore, limestone, and coke in an electric or a blast furnace, pig-iron being a by-product, while the slag, when finally ground, constitutes the cement. Probably they can be economically made where titaniferous magnetite is abundant, as in the Saguenay district in Quebec.

A good cement of pleasing light red colour and puzzolanic character, harder than ordinary Portland cement, and of great tensile strength, can be prepared from the spent shale of the Scottish oil-fields, while at a cement works at Redwood City, California, oyster-shell deposits are used as the source of the required calcium carbonate.

Roman cement is made from natural mixtures of lime and clay, such as septenium (cement stone), by calcination in kilns with subsequent grinding and sifting. It has quick-setting property which makes it valuable for work requiring rapid erection—as, for instance, on work between tides—but is only of medium strength. (See Septaria.)

The "Lightning" brand of cement made by melting bauxite with lime is of highly aluminous character, a typical analysis showing 40 per cent. alumina, 40 per cent. lime, 10 per cent. silica, and 10 per cent. iron oxide. It is said to have great strength at 24 hours, being then as

CEMENT (*Continued*)—
strong as ordinary Portland cement at a month or more, so that it is of special value when speed of construction is of paramount importance and for endurance in sea-water.

Keene's cement is stated to be produced by the calcination of gypsum or the recalcination of the partially calcined material which has been made to take up a quantity of aluminium sulphate or alum solution.

The cracking and gradual disintegration of breeze blocks made from Portland cement and clinker, as used in the building trade for making walls, etc., is now attributed to the presence of unburned or partially burned coal in the clinker, particularly when coal liable to spontaneous combustion is employed.

The output of cement for building and engineering purposes for works in Great Britain in 1924 was more than three million tons.

Other references: "The Evaluation of Portland Cement by a New Method of Determination of the Size of the Particle," by S. Dickson (*J.S.C.I.*, 1931, **50**, 295 T); "Constitution of Cements," by N. P. Costa (*B.C.A.*, 1930, B, 863); "Iron-Cementing Compositions" (*C.T.J.*, 1920, **67**, 323); "Coloured Portland Cement" (*C.T.J.*, 1927, **81**, 233, and *B.C.A.*, 1927, B, 787); "Some Acid-Resisting Cements" (*Ind. Chem.*, 1925, i., 209); "Cement Manufacture," by James Watson (*Ind. Chem.*, 1925, i., 231); two papers by S. Dickson and R. H. H. Stanger respectively (*J.S.C.I.*, 1926, **45**, 310 T and 312 T); notes on "Fireproof Cements" (*Ind. Chem.*, 1927, iii., 226); J. W. Cobb (*J.S.C.I.*, 1910, **29**, 69 T); H. Kühl (*B.C.A.*, 1931, B, 159); "Cement Chemistry in Theory and Practice," by H. Kühl (*B.C.A.*, 1931, p. 541); Special Report, No. 8, of the Building Research Board (H.M. Stationery Office); E. C. Eckel on *Cements, Limes, and Plasters*, 3rd edition (Chapman and Hall, London); and R. K. Meade on *Portland Cement* (Chem. Publishing Co., Ltd., Williams and Norgate, London). See also Adhesives, Bricks, Calcium (Plaster of Paris), Concrete, Lutes, Marine Glue, "Permac," "Prodorite," "Roskitt," Sealing Wax, "Sorel Cement," Spence Metal, Red Lead, and White Lead.

CENOSHERES (of Coke)—See Coal (p. 211) and Coke (p. 221).

CENTIGRADE—See Heat.

CENTIMETRE—See Weights and Measures.

CENTRIFUGES (Hydro-Extractors)—Machines for extracting liquids from pastes, precipitating fine solids suspended in liquids, and for separating liquids of varying specific gravities by centrifugal action. In the separation of liquid from liquid and solid mixtures by rotation of the mixture in a cage or drum, the liquid is expelled through openings therein. Super-centrifugal force is now used in drying operations, the clarification of varnish, lacquers, enamels, in the extraction of honey from honeycombs, and for the separation of immiscible liquids, the commercial type of machine employed being capable of generating a force 17,000 times that of gravity, and dealing with from 25 to 150 gallons of material per hour.

The ultra-centrifuge is an apparatus for the study of changes in fine-

CENTRIFUGES (*Continued*)—

grained sols during centrifuging, from which the size and distribution of particles may be calculated. (See Svedberg and Rinde (*J.C.S.* 1925 *Abs.*, March, 1925, **11**, 233); "The Electrical Operation of Centrifugals" (*Chem. and Ind.*, 1929, **48**, 482).) A new heated centrifuge, consisting essentially of four tube furnaces, specially suitable for smeltings works is described (*Ind. Chem.*, 1928, iv., 432); see also *C.T.J.*, 1924, **75**, 94; *Centrifugal Dryers and Separators,* by E. A. Alliott (Ernest Benn, Ltd., London); Particles and Porcelain.

CEPHALINE—See Ipecacuanha.

"CERALOSE"—See Glucose.

CERAMICS—Pertaining to pottery. (See paper on "Grog," by C. R. F. Threlfall (Trans. Ceram. Soc., 1931, **30**, 1-18) and other publications of the Ceramic Society; *Encyclopædia of the Ceramic Industries,* by A. E. Searle (E. Benn, Ltd., London); *Ceramic Chemistry,* by H. H. Stephenson (David Bros., Manchester); also Bricks, Clays, Glass, Porcelain, Refractones, Silica, and Stoneware.)

CERARGYRITE—See Horn Silver.

"CERATHERM"—An earthenware or porcelain-like material for lining vats, and used in the construction of pumps for the dye industry.

CEREAL CHEMISTRY—See Amylases and Wheat.

CEREBRINE—See Brain Matter.

CERESINE—See Ozokerite and Waxes.

CERITE—A rare mineral, of crystal system, No. 4, and sp. gr. 4·75 to 5, found in Sweden, being a hydrated silicate of cerium, containing also lanthanum and praseodymium (from which cerium is extracted).

CERIUM (Ce) **and its Compounds**—Atomic weight, 140·2; sp. gr. 7; m.p., about 623° C.; a rare element found in association with lanthanum in the Swedish minerals *cerite, allanite,* and *orthite,* also in *gadolinite, wöhlerite,* and *monazite.* It is malleable, ductile, resembles iron in appearance, oxidizes quickly in moist air, forms alloys with iron, aluminium, zinc, magnesium, and combines with boron and silicon. It is credited with two isotopes, and made by electrolysis of the fused chloride.

There are two oxides, Ce_2O_3 and CeO_2, the latter of which (ceria) is used in the preparation of mantles for use in incandescent gas lighting.

Cerium nitrate ($Ce(NO_3)_3.6H_2O$) is a red crystalline salt soluble in water; the chloride ($CeCl_6.14H_2O$) is a reddish crystalline compound also soluble in water; while cerium-ammonium nitrate ($Ce_2(NO_3)_6 3NH_4NO_3.10H_2O$) is a white crystalline soluble salt; all three compounds being used in the preparation of incandescent gas mantles.

The sulphate ($Ce(SO_4)_2.4H_2O$) is a reddish-yellow crystalline, powerful oxidizing agent; is soluble in water and used in photography.

Cerium sulphide is described by Picon (*B.C.A.*, 1931, A, 582).

The oxalate ($Ce_2(C_2O_4)_3 9H_2O$) and the insoluble fluoride ($CeF_4.H_2O$) (by-products in the manufacture of thorium from monazite sand) were both used during the war in connection with searchlights and tracer bullets; the fluoride is also used in ceramics. The oxalate is but slightly soluble in water, and, in addition to its other uses, is employed medicin-

CERIUM (*Continued*)—
ally for the prevention of chronic vomiting. Cerium compounds are also used as catalysts in making aniline black and as reducing agents in photography. (See Gas Mantles, also Iron (Ferrocerium).)

CEROTIC ACID ($C_{26}H_{52}O_2$)—A crystalline fatty acid, m.p. 85° to 85·5° C., of the normal series, which can be extracted from the dry spores of *Aspidium filix,* and is an important constituent of beeswax, being contained in combination as ceryl cerotate ($C_{25}H_{51}.CO.OC_{26}H_{53}$) in Chinese wax. It is soluble in hot alcohol, and can be obtained from Chinese wax by melting that substance with potash or by its dry distillation, and from paraffin wax by oxidation with chromic acid. (See Waxes (Beeswax).)

CEROTIN—Chinese wax. (See Waxes.)

CERULEAN BLUE—A light blue pigment or artist's colour made by heating together copper sulphate, tin oxide, and precipitated silica or chalk.

CERUSE—Lead carbonate or white lead.

CERUSSITE—A mineral lead carbonate ($PbCO_3$) occurring in Cornwall, Cumberland, Siberia, and the U.S.A., of crystal system, No. 4, and sp. gr. 6·5. (See Lead.)

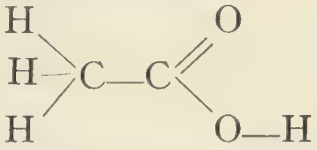
CERYL CEROTATE ($C_{25}H_{51}.CO.OC_{26}H_{53}$)—A constituent of Chinese wax, which has also been isolated from sunflower oil. (See Cerotic Acid.)

CETIN—See Waxes (Spermaceti).

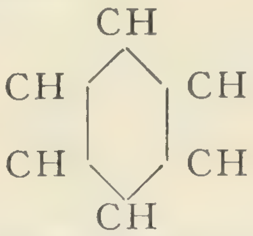
CEVADINE—See Veratrine.

C.G.S.—See Force.

CHAINS—Theoretical views of atomic arrangements of several classes. Open chains are regarded as having terminal atoms not mutually in combination, by which, for example, aliphatic combinations, such as the olefines and paraffins, are characterized; thus, acetic acid is represented constitutionally by the formula:



In closed chains, the terminal atoms are regarded as mutually combined, forming a ring, as in benzene:



In so-called "fork" chains, two new chains are produced at some point, both of which are attached to the parent chain, and "side" chains present a chain of atoms in combination with a longer chain either open or ring shaped. With respect to intermediate carbon rings containing 3, 4 or 5 atms. carbon, see lecture by W. H. Perkin (*J.C.S.*, 1929, pp. 1347-1363; also Acyclic, Aliphatic, Benzene Ring, Rings, and Valencies.

CHALCANTHITE—Native copper sulphate ($CuSO_4,5H_2O$) (crystal system, No. 6, and sp. gr. 2·21) found in some Chilian mines, Arizona, etc.

CHALCEDONY (**Onyx**)—A variety of quartz, of crystal system, No. 3, and sp. gr. 2·6, found in Bithynia and elsewhere. (See Silicon and Cornelians.)

CHALCOCITE (**Redruthite**)—Mineral copper sulphide (Cu_2S), of crystal system, No. 4, and sp. gr. about 5·5. (See Copper.)

CHALCOLITE—A rare mineral ($CuO,UO_3,P_2O_5,8H_2O$), of crystal system, No. 2, and sp. gr. about 3·5. (See "Chemistry of Leaching Chalcolite," by J. D. Sullivan (*B.C.A.*, 1930, B, 1064).

CHALK—See Calcium (Carbonate).

CHALYBEATE WATERS—Natural waters containing iron as ferrous carbonate in a state of solution, constituting valuable tonics in cases of debility. Such waters are found and used medicinally at Tunbridge Wells, Cheltenham, Harrogate, Leamington, Scarborough, Strathpeffer, and elsewhere.

CHAMOMILES—The expanded flower-heads of *Anthemis nobilis,* a genus of Compositæ, growing wild in South England, and cultivated in Hampshire, Surrey, France, Belgium, etc. They yield 0·7 to 1 per cent. of a volatile oil, to which their odour is due, have a bitter taste, and are used in medicine.

CHANCE PROCESS—See Sulphur (Recovery).

CHARCOAL—See M. S. Shah on the "Combustion of Charcoal" (*J.C.S.*, 1929, p. 2261) and Carbon.

CHARTS—See Data Sheets and Nomograms.

CHAULMOOGRA OIL—A thick, yellowish-brown oil or soft fat, of acrid taste, expressed from the seeds of *Taraktogenos kurzii* and *H. Wightiana;* m.p. 33° to 39° C., sp. gr. 0·9425, sap. v. 210·4, acid value 21 to 27, and i.v. (Hanus) 96; used in medicine; soluble in alcohol, ether, etc. The seeds, which are imported from Burma, Assam, and Siam, yield about 33 to 50 per cent. of the oil, which contains chaulmoogric ($C_{18}H_{32}O_2$), hydnocarpic ($C_{16}H_{28}O_2$), taraktogenic ($C_{36}H_{60}O_6$), and isogadoleic ($C_{20}H_{38}O_2$) acids, etc. For further information concerning the glycerides of chaulmoogra oil see A. Bömer and H. Engel (*Analyst,* 1929, **54,** 423). Ethyl chaulmoograte (the ethyl ester of the fatty acids of the oil) is used in the treatment of leprosy. The oil from *Oncoba echinata* (Gorli oil), a native of Sierra Leone, French Guinea, and the Ivory Coast of W. Africa, is stated to afford a satisfactory substitute for chaulmoogra oil. It has a sp. gr. of 0·9286 at 30° C., m.p. 40° to 42° C., sap. v. 184·5, and i.v. (Hanus) 98, containing 75 to 80 per cent. of chaulmoogric acid. (See André and Jonatte, *Analyst,* 1928, **53,** 604; D. R. Koolhaas, *B.C.A.*, 1930, B, 292; and description of Burmese species by Peacock and Aiyar (*B.C.A.*, 1931, B, 552); Hydnocarpus Oil, "Moogrol," and Taifushi Oil.)

CHEDDITE—See Explosives.

CHEESE—of which there are many varieties—is ordinarily made from milk by coagulation with rennet, and represents its casein (albuminous) constituent with some of its butter. It undergoes certain chemical changes upon keeping, which are not well understood, and is a valuable

CHEESE (*Continued*)—

food. It varies in composition according to the milk from which it is made and to details in the process of manufacture, containing from 30 to 60 per cent. water, 2¼ to 5½ per cent. nitrogen, from 19 to upwards of 45 per cent. fat, and from 4½ to 7 per cent. mineral substances (ash). Roquefort cheese is made from a mixture of sheep's and goat's milk, and Gruyère cheese, containing about from 40 to 45 per cent. fat (originally made from goat's milk), made from cow's milk. (See A. Burr on "Water Content of Cheese" (*B.C.A.*, 1929, B, 621); P. Sajous on "Gruyère Cheese" (*B.C.A.*, 1930, B, 1044); Teichert and Stocker on "Spanish Cheese made from Ewe's Milk" (*B.C.A.*, 1931, B, 364); and Templeton and Sommer on "Processed Cheese" (*B.C.A.*, 1930, B, 1044); Casein and Milk.)

CHELATION (**Cheliform**)—Particular co-ordinated groups. (See Co-ordination.)

CHELIDONINE—A colourless crystalline alkaloid ($C_{20}H_{19}NO_5,H_2O$), extracted from *Chelidonium majus,* soluble in alcohol and ether, and which forms an additive hydrochloride soluble in water and alcohol; both preparations are used medicinally. (See Sparteine Sulphate.)

"CHEMIC"—A trade designation for hypochlorite of lime.

CHEMICAL AFFINITY—See Atoms, Chemical Interactions, Elements, Radio-activity, and Valencies.

CHEMICAL COMPOUNDS—There is a fundamental difference between a mere mixture and a chemical compound. Lead shots mixed with powdered sulphur can be easily separated again, the sulphur can be blown away from the mixture by use of a bellows, or all the shots can be mechanically picked out and removed one by one. But if, instead of removing the shots, the mixture is subjected to strong heat, both the lead and the sulphur disappear as individuals, and enter into combination with each other, a chemical *compound* being formed, named lead sulphide, which has properties quite different from those of its constituents.

Again, iron filings may be mixed ever so intimately with sand, but only as a mere mixture; all the iron filings may be separated or withdrawn from the mixture by means of a magnet, which attracts the iron and not the sand.

When mercury (quicksilver) is sufficiently heated while exposed to the air, it becomes changed into a yellow compound of the mercury and atmospheric oxygen (an oxide of mercury), and by no mechanical process can the constituents of which it is compounded be separated from each other.

Chemical combination always takes place in so-called equivalent weights—that is, definite combining proportions of the substances concerned—the combining weights of the elements being the smallest which will combine with 1 part of hydrogen or 8 parts by weight of oxygen.

In many cases, these equivalent weights are identical with the atomic weights of the same elements, but not in all cases. For instance, oxygen

CHEMICAL COMPOUNDS (*Continued*)—

requires 2 atoms of hydrogen for its saturation to produce a molecule of water (H_2O), and as the relative weight of hydrogen as the standard is 1, that of oxygen is 8. Sulphur also requires 2 atoms of hydrogen to satisfy its affinity, and while its atomic weight is 32 its equivalent weight is 16. Phosphorus and arsenic each requires 3 atoms of hydrogen, and this varying power of continuation of the elements is termed valency. (See Molecules and Valencies.)

Salt (sodium chloride) is a chemical combination of 23 parts by weight of the metal sodium and 35½ parts by weight of the gas chlorine; or, in other words, a combination of one atom of each of these two elements. The two atoms thus combined make up a *molecule*, so that the molecular weight of the compound (salt) is that of the two added together—namely, 58½. When salt is decomposed—that is, split up by chemical means into its two constituent elements—58½ parts by weight always yield 23 parts by weight of sodium and 35½ parts by weight of chlorine.

Oxides, Hydroxides, Bases, and Salts—The oxides include combinations of the metals such as potassium, sodium, calcium, magnesium, and strontium with oxygen, and these oxides by combination with water form *hydroxides*, the potassium and calcium compound being represented respectively as follows:

Oxides.	Hydroxides.
$K_2O + H_2O$	$2KHO$
$CaO + H_2O$	CaH_2O_2

The higher oxides are known as peroxides.

Ammonium hydroxide is a combination of 1 atom of nitrogen with 5 atoms of hydrogen and 1 atom of oxygen (NH_4HO). These compounds, as also the carbonates (see Carbonic Acid), all behave as bases, and by interaction with acids form corresponding salts. (See Bases.)

When an acid solution is mixed with its equivalent quantity of an alkaline or other basic solution, the acid character of the one solution and the alkaline or basic character of the other solution are severally destroyed or *neutralized*. For example, if a solution of sodium hydroxide in water be mixed with one of hydrochloric acid, a chemical interaction takes place, and sodium chloride is produced in solution. This is represented by formulæ or equation as follows:

$$NaHO + HCl = NaCl + H_2O,$$

and if the neutral solution which results from this reaction be heated so as to cause evaporation of sufficient of the water, the salt will be obtained upon cooling of the solution in a crystalline condition.

Similarly, when lime is treated with hydrochloric, nitric, or sulphuric acid, it enters into combination and forms the corresponding salts—viz., calcium chloride, nitrate, or sulphate, as the case may be. Thus, if hydrochloric acid be employed, the change is expressed as follows: $CaO + 2HCl = CaCl_2 + H_2O$; with nitric acid as follows: $CaO + 2HNO_3 = Ca(NO_3)_2 + H_2O$; and with sulphuric acid as follows: $CaO + H_2SO_4 = CaSO_4 + H_2O$.

CHEMICAL COMPOUNDS (*Continued*)—

The chloride and nitrate of calcium are both soluble in water, but the sulphate is almost insoluble.

Chlorides, Bromides, Iodides, and Other Compounds—If in place of oxygen, the elements chlorine, bromine, iodine, fluorine, and sulphur be severally taken and made to combine with metals or other bases, the resulting compounds are *chlorides, bromides, iodides, fluorides,* and *sulphides.*

This is shown in tabulated form as below:

Compounds of—	Called—	Example.	Formula.
Oxygen	Oxides	Zinc oxide	ZnO
Chlorine	Chlorides	Sodium chloride	$NaCl$
Bromine	Bromides	Potassium bromide	KBr
Iodine	Iodides	Potassium iodide	KI
Fluorine	Fluorides	Calcium fluoride	CaF_2
Sulphur	Sulphides	Lead sulphide	PbS

The names used to identify chemical substances are designed as far as possible to indicate their composition, but the system is by no means perfect, and, apart from other variations, many old common or familiar names are still retained.

It frequently happens that the same two chemical elements combine together in various proportions, so forming as many different compounds, and to distinguish these, terminal letters or prefixes are employed. For instance, the two compounds water and hydrogen dioxide (H_2O and H_2O_2 respectively) are both composed of hydrogen and water, so the one with the higher proportion of oxygen is styled hydrogen dioxide or peroxide, water being hydrogen monoxide.

Again, phosphorus combines with chlorine to form two chlorides PCl_3 and PCl_5, and these are termed respectively phosphor*ous* chloride and phosphor*ic* chloride, or preferably phosphorus *tri*chloride and phosphorus *penta*chloride respectively.

Acids are commonly called by their familiar names, but may be, and often are, described as compounds of hydrogen—for instance:

Hydrochloric acid = Hydrogen chloride.
Nitric acid = Hydrogen nitrate.
Sulphuric acid = Hydrogen sulphate.

The terminals *ic* and *ous* are used to denote acids with the greater and smaller proportion of oxygen, where that element enters into their combinations; thus we get: Sulphur*ic* acid, formed from sulphur *tri*oxide and water: $SO_3 + H_2O = H_2SO_4$; sulphur*ous* acid, formed from sulphur *di*oxide and water: $SO_2 + H_2O = H_2SO_3$; nitr*ic* acid, formed from nitrogen *pent*oxide and water: $N_2O_5 + H_2O = 2HNO_3$; nitr*ous* acid, formed from nitrogen *tri*oxide and water: $N_2O_3 + H_2O = 2HNO_2$.

When these acids combine with bases—for example, potassium oxide—they form respectively sulph*ate*, sulph*ite*, nitr*ate*, and nitr*ite* of potassium; or, instead of expressing them as named, they may be described as potassium sulphate, sulphite, nitrate, and nitrite respectively.

CHEMICAL COMPOUNDS (*Continued*)—

Some metals, including copper, iron, mercury, and tin, form two compounds of most of the classes, and these are indicated by the terminations of the metallic names; thus, ferr*ic* chloride is $FeCl_3$, and ferr*ous* chloride is $FeCl_2$; mercur*ic* chloride is $HgCl_2$, and mercur*ous* chloride is Hg_2Cl_2, and so forth. The names of the compounds containing the larger proportion of metal end with the termination *ous*, and those with the smaller proportion with the ending *ic*.

Carbonates, Carbides, Nitrides, Hydrides, and Phosphides are described under these respective headings.

Silicon, Boron, and Selenium in combination with metals form silicides, borides, and selenides, and the more important ones find description under other headings.

Anhydrides as a class are related to the acid-forming oxides, such as sulphur trioxide (SO_3), which by combination with water gives sulphuric acid, $SO_3 + H_2O = H_2SO_4$. By abstracting or taking away the water from sulphuric acid it is reduced to its anhydride. The term, however, is used more generally. (See Anhydrides.)

Cyanides—See Cyanogen.

Arsines, Phosphines, and Stibines—Very oxidizable compounds formed by replacing hydrogen of arsenic hydride (As_2H_3), hydrogen phosphide (PH_3), and antimony hydride (SbH_3) by hydrocarbon groups.

Hydrosulphides—See Hydrosulphides and Nomenclature.

CHEMICAL CONSTANTS—See Constants (Chemical and Critical Constants).

CHEMICAL ELEMENTS—See Elements.

CHEMICAL ENGINEERING—In a paper dealing with the design of chemical plant, in which particular attention is directed to the subject of model experiments in chemical engineering (*Ind. Chem.*, 1930, vi., 482), R. Edgeworth-Johnstone expresses the view "that the principle of dynamic similarity, combined with the film concept, provides a valuable means of arriving at the relationship between the behaviour of models and their full-scale prototypes. Through the conception of geometrically similar streamline films, the relationship between the two systems reduces to a matter of simple rule-of-three."

References: "The Training of the Chemical Engineer," by J. W. Hinchley (*Chem. and Ind.*, 1929, **48**, 1171); "Chemical Eingineering, Education, etc.," by W. E. Gibbs (*Chem. and Ind.*, 1928, **47**, 1305); "Surface Energy and Chemical Engineering," by W. E. Gibbs (*Ind. Chem.*, 1929, v., 447; and 1930, vi., 78, 113, and 273); "The Growth of the British Chemical Engineering Industry" (*Ind. Chem.*, 1931, vii., 5 and 284); "Works Costs and the Small Chemical Factory," by W. H. Simmons (*Ind. Chem.*, 1929, v., 478); "Control Methods in the Chemical Industry," by G. A. Perley (*Chem. and Ind.*, 1931, **50**, 452); *Chem. and Ind.*, 1926, **45**, 957, and 1927, **46**, 724-728; J. H. Hinchley (*Ind. Chem.*, 1927, iii., 7; 1928, iv., 4 and 71; and 1929, v., 49; and 1930, vi., 53); C. H. Butcher (*Ind. Chem.*, 1928, iv., 47, 91, 135, 199, 355, 415; 1929, v., 25; 1930, vi., 95, 139, 199, 404; 1931, vi., 95);

CHEMICAL ENGINEERING (*Continued*)—

A. J. Underwood (*Ind. Chem.*, 1927, iii., 179; *Chem. and Ind.*, 1929, **48,** 33); *C.T.J.*, 1927, **80,** 279, and 1928, **81,** 191; *Chemical Engineering Trade Literature Supplement* (*J.S.C.I.*, 1930, **49,** 2 and S 34); *Principles of Chemical Engineering,* by Walker, Lewis, and McAdams (McGraw Hill Co.); *Handbook of Chemical Engineering,* by G. E. Davis (Davis Bros., Manchester); *Elements of Chemical Engineering,* by Badger and McCabe (McGraw Hill Co., 1931); *Industrial Chemical Calculations,* by O. A. Hougen (Chapman and Hall); also Chemical Plant, Data Sheets, Heat, Nomograms, Nomographs, Power Standard Specifications, and Welding.

CHEMICAL ENGINEERING CHARTS—See Nomograms.

CHEMICAL EQUATIONS—See Chemical Interactions.

CHEMICAL FORMULÆ—See Chemical Compounds, Elements, and Formulæ.

CHEMICAL INTERACTIONS (Affinity, Reactions, and Equations)—Chemistry is well defined as the study of the laws of changes of matter. All articles of food and clothing, building materials, and those needed for decoration or repair, every art and every industry—all depend essentially for their production or conduct upon chemical changes as realized in nature or made by man to serve human purposes. The same is true of the production and decay of animal and vegetable matters, as also the processes by which they are broken up and the resulting products made available in their turn as food for new life; the very diseases of mankind and animals and their treatment are all chemical in essence and involve chemical changes. These chemical changes constitute a sort of adaptation of matter to environment, and in a sense are acts of creation, as every such change produces products which, although related, are quite distinct in character and properties from the original substances which give rise to them when subjected to the required influences. Thus, in a very literal sense all matter—which, as will be seen in other places, appears to be essentially one in ultimate nature—is actuated by a spirit of life, being susceptible to change when the environment is appropriate. In other words, the liability to change is equivalent to a kind of life.

If some broken marble (calcium carbonate) be placed in a dilute solution of hydrochloric acid, a reaction occurs attended with effervescence, due to the escape of carbon dioxide gas, the chemical change that takes place between the marble and the acid being expressed as follows:

$$\mathrm{CaCO_3}\ \text{(calcium carbonate)} + \mathrm{2HCl}\ \text{(hydrochloric acid)} = \\ \mathrm{CaCl_2}\ \text{(calcium chloride)} + \mathrm{H_2O}\ \text{(water)} + \mathrm{CO_2}\ \text{(carbon dioxide).}$$

In other words, 1 molecule of calcium carbonate and 2 molecules of hydrochloric acid produce 1 molecule of calcium chloride, 1 molecule of water (both of which remain in solution), and 1 molecule of gaseous carbon dioxide.

In this interaction between a solid body and a liquid, one product is gaseous in character, although it can, in point of fact, be converted into the liquid state and even made into a solid form like snow by great

CHEMICAL INTERACTIONS (*Continued*)—
cooling under pressure—that is to say, by squeezing (pumping) a great volume of the carbon dioxide gas into a very small space whilst cooling or freezing it at the same time.

Mercuric chloride is a compound of mercury with chlorine, and if a strip of copper be placed in a slightly acid solution of that substance, a change takes place, causing the mercury to be deposited, and after sufficient time, nothing but chloride of copper is found in solution. In other words, the mercury is replaced (owing to the chemical change that takes place) by the copper, and it is found in practice that this exchange takes place in the proportion of 200·6 parts of mercury and 63·5 parts of copper. If this solution of chloride of copper be taken afterwards and exposed in turn to the action of a piece of iron, the whole of the copper can be deposited from the solution and replaced by iron; and now it is found that the metals are again exchanged in their equivalent weights, 63·5 parts copper being replaced by 56 parts iron. These two changes or interactions are expressed by the two following chemical equations:

$$HgCl_2 \text{ (mercuric chloride)} + Cu \text{ (copper)} = CuCl_2 \text{ (cupric chloride)} + Hg \text{ (mercury)}.$$

$$CuCl_2 \text{ (cupric chloride)} + Fe \text{ (iron)} = FeCl_2 \text{ (ferrous chloride)} + Cu \text{ (copper)}.$$

Baryta or barium oxide is represented by the formula BaO, but there is another oxide of barium, known as barium dioxide, which has the formula BaO_2. Now, when powdered barium dioxide is added to a solution of dilute hydrochloric acid (which has the constitution represented by the formula HCl), the following change takes place:

$$BaO_2 + 2HCl = BaCl_2 + H_2O_2.$$

This chemical equation represents the fact that 1 molecule of barium dioxide interacting with 2 molecules of hydrochloric acid (hydrogen chloride) produces 1 molecule of barium chloride and 1 molecule of hydrogen dioxide, both of which, being soluble in water, remain together in solution.

It is further evident that the sum of the products is equal to the sum of the substances originally employed, and the equation given above shows that there are employed in this chemical interaction:

1 atom or	137 parts by weight	of barium	As contained in 1 molecule of barium dioxide.
2 atoms or	32 ,, ,,	of oxygen	
2 ,, ,,	2 ,, ,,	of hydrogen	As contained in 2 molecules of hydrochloric acid,
2 ,, ,,	71 ,, ,,	of chlorine	

totalling 7 atoms and 242 parts by weight ;

and that there are produced—

1 atom or	137 parts by weight	of barium	As contained in 1 molecule of barium chloride.
2 atoms or	71 ,, ,,	of chlorine	
2 ,, ,,	2 ,, ,,	of hydrogen	As contained in 1 molecule of hydrogen dioxide,
2 ,, ,,	32 ,, ,,	of oxygen	

totalling 7 atoms and 242 parts by weight.

Incidentally, this equation also affords an illustration of the indestructibility of matter.

If in the study of any chemical change, the sum of the products found upon analysis is not equal to the parts by weight of the sub-

CHEMICAL INTERACTIONS (*Continued*)—

stances employed, it is known to the operator that the analysis is imperfect.

The rate of chemical interaction is proportional to the active masses of the substances involved therein, and several reactions may take place concurrently on independent lines. (See Mass Action.)

Chemical reactions can occur between substances in the solid states as well as in the gaseous and liquid forms, bringing about, for example, the changes frequently experienced in alloys by heating and cooling, while the fact of diffusion is well established. (See Diffusion.) For example, lead oxide and molybdenum trioxide, as also carbon and silicon, react vigorously at elevated temperatures. It is important to bear in mind that most chemical interactions as experienced in general work are those which take place in the presence of air and exposure to light, both of which factors have a bearing upon many of such chemical changes.

They can often be induced or accelerated by others taking place simultaneously in the same admixtures, or by the use of other substances acting as catalysts or so-called accelerators (see Catalysis and Rubber), and when they proceed to perfection—that is, until all the factors are exhausted—they are termed irreversible.

Baly has expressed the view that probably reactions never take place between absolutely pure substances; the molecules have to be activated —that is, raised to a higher level of energy. The presence of some agency in the nature of a catalyst is necessary, water being the most effective in the domain of inorganic chemistry. The process in organic chemistry is more complicated, a special catalyst being required for each stage of reaction.

The effects of moisture in chemical and physical changes is the subject of a book by J. W. Smith (Longmans and Co., 1929), who has himself contributed to knowledge of such effects, showing among other things that the removal of moisture causes the stoppage of reaction between sulphur vapour and silver up to about 150° C. (*J.C.S.*, 1931, p. 860); and a review of this book, by H. B. Dixon, another authority on the subject is published in *Chem. and Ind.*, 1930, **49**, 270. (See also Drying (Intensive).)

Reversible or balanced reactions are those in which the products react so that a state of equilibrium is reached, the concentration of factors and products being balanced—*e.g.*:

$$CH_3COOH + C_2H_5OH \Longleftrightarrow CH_3COO,C_2H_5 + H_2O,$$

this equation representing both the production of ethyl acetate from acetic acid and ethyl alcohol, and the re-formation of ethyl alcohol and acetic acid at a definite temperature. In other words, the velocity of the esterification process is balanced by that of the hydrolysis. Such reactions are quite common, and in all probability most chemical interactions are reversible.

(For detailed information of the various *classes* of reactions, see Couch's *Dictionary of Chemical Terms*, pp. 159-162 (D. Van Nostrand Company, New York).)

CHEMICAL INTERACTIONS (*Continued*)—

The force which brings about chemical combination and keeps the resulting products comparatively intact as entities is correlated to other forms of force, such as heat, light, and electricity. All such changes involve the consumption or expenditure of energy, many being attended by the absorption or production of heat and development of light or electricity. A true measure of chemical affinity is the free energy change in chemical interaction, and in many cases this can be calculated from the heat of reaction, specific heats, etc. (See Entropy.)

The energy required in the form of electric current to decompose water into its constituent elements is identical with the energy transformed into heat evolved in the combination of the two gases (hydrogen and oxygen) to form water. That this energy change is probably electrolytic in character is supported by recent investigations. Armstrong (H. E.) has expressed the view that the interaction of two diverse molecular systems is determined by the presence of a third system, itself of an electrolytic character, and compatible with them in the sense that the three can be associated with a single conducting system, the third one being the determinant.

Energy changes, involving the use of high and low temperatures, low and high pressures (sometimes to the extent of 50,000 atmospheres), as pointed out elsewhere (see Force and Pressure (High)), are not shown by the formulæ used by chemists to represent equational changes; they represent only the materials and the quantities involved.

The view has been expressed that chemical combination is due to the mutual attraction between the positive nucleus of one atom and an electron belonging wholly or partly to another atom; another view is that chemical actions depend almost exclusively on the revolving electrons in the atoms or molecules, and are scarcely affected by the nuclei; while G. N. Lewis thinks there are certain "levels" in the molecule along which the electrons move, so that they are able to move from one level to another, giving out or receiving energy in the process corresponding to the emission or reception of light.

The generally accepted chemical view is that reaction is attributable to activated molecules possessing a critical increment of energy above the average, as illustrated by the behaviour of activated and nascent forms of chemical entities. The quantity of energy requisite to bring each molecule from its initial to its reactive stage has been termed the "critical increment" characteristic of the specific reaction, and Baly has done much towards the confirmation of this "radiation" theory of chemical reaction. (See *Chem. and Ind.*, 1928, **47,** 914-925); discussion on the "Critical Increment of Homogeneous Reactions," December 17, 1931 (Chemical Society, London); Co-ordination, Electrons, Quantum Theory, and Valencies.)

CHEMICAL LITERATURE—See "Guide to," by Crane and Patterson (John Wiley and Sons, Inc., N.Y.; or Chapman and Hall); *A Catalogue of British Scientific and Technical Books,* by Daphne Shaw (A. and F. Denny (1930)), and Annual Reports of the Chemical Society and the Society of Chemical Industry.

CHEMICAL PLANT means the implements and machinery required for the production of chemicals on a large scale, and involves the application of engineering drawings and construction, and a knowledge of the properties of the materials to be employed—questions of heat-absorption and evolution, its transfer and transmission, and other fundamental principles, including calculations as to the quantities and capacities to be dealt with by the various sections; in other words, the magnification of those conditions ascertained in laboratory practice to realise the best results attainable.

The nature of the materials of the apparatus (plant) to be employed depends largely upon the chemical characters of the substances to be dealt with, physical laws, and the interactions involved.

The operations include handling, transporting, heating, digesting, extracting, leaching, agitating (mixing), washing, pulverizing, grinding, disintegrating, masticating, screening, evaporating, distilling, filtering, emulsifying, crystallizing, separating, drying, pumping, compressing gases, scrubbing gases, condensing gases and liquids, sublimating, measuring, gauging, refrigerating, roasting, calcining, etc., and these necessarily call for appropriate appliances for carrying them out, and for generating the power required to effect the operations.

These subjects form the essential business of the chemical engineer, who should therefore not only have knowledge or access thereto of the chemistry of the processes involved, but also a good knowledge of engineering and sound judgment in appraisement of values and costs, the cost of production being an all-important factor in chemical industry.

Reinforced concrete buildings are eminently suitable for plant-housing, and it does not always pay to remodel an old chemical plant, every case having to be determined on its own merits.

Concrete is largely used in the construction of tanks and containers, many liquids, as, for instance, linseed oil, rosin oil, and certain fish oils, being of such character as to admit of storage in concrete tanks without any protective covering. A coating of sodium silicate, good cement-wash, oil-proofing enamel, bitumen, bakelite varnish, or other material, enables a much greater use to be made of such and other kinds of tanks, the nature of the protective coating being chosen according to that of the liquids to be stored therein. Impregnation with sulphur sprayed on under pressure in a molten state is now the subject of a patented process for rendering concrete vessels acid-resisting in character. (See Sulphur.)

Wood is unsuitable for the construction of apparatus where contact with strong oxidizing agents (such as concentrated nitric and sulphuric acids) is concerned, and it is readily attacked by strong alkalies, besides being mechanically weaker than metals, liable to swell in contact with many aqueous solutions, and to be attacked by fungoid growths. All the same, hard woods can be usefully employed for the construction of storage vessels if free from resinous matters liable to attack by solvents of them, and therefore available for dealing with many neutral solutions and gases. Thus, wooden pipes can be used for conveying sulphite pulp and dilute sulphuric acid, benzol, for oil-refining, and use in galvaniz-

CHEMICAL PLANT (*Continued*)—

ing; also for carbon dioxide gas in white-lead factories and catch-towers for hydrofluoric acid as generated in acid phosphate manufacture.

Red-wood and oak are apt to colour liquids; fir and pine will often impart flavouring to liquids; while oak, maple, and red-wood exhibit the greatest absorptive characters, and fir, cypress, and pine the least. (See A. H. Loveless (*Ind. Chem.*, 1932, viii., 104) and Wood.)

Probably, cast-iron lined with acid-resisting enamel is more widely used than any other material for the construction of chemical plant, including centrifugal pumps, and it is of importance that the enamel should be lead-free. Great progress has been made in successfully increasing the silicon content of iron, with corresponding resistance to acid attack, but this is unfortunately attended with loss of mechanical strength and decreased facility for casting. It should contain not less than 14 per cent. silicon and a maximum of 0·8 per cent. carbon. Iron with less than 12 per cent. silicon is stated to be attacked by dilute sulphuric acid ten times as much as that containing 14 per cent.

Steam and water-jacketed pans made of aluminium are useful for many operations, such as for crystallizing ammonium sulphate, while tin is most useful for the construction of apparatus concerned with the essential oil, perfume, and other industries.

References to the uses of lead, aluminium, tin, iron, steel, copper, and other metals will be found under their respective headings, while chemical stoneware is referred to under that heading and those of Clay and Porcelain.

Much assistance is given in the control of chemical operations by use of various scientific instruments, such as the Coolidge X-ray tube for the examination of thick masses of metals, ascertaining the quality of electric and acetylene welds, uneven distribution of any particular constituent of alloys, and for the examination of timber.

The spectroscope is useful for the discovery of detrimental constituents of alloys, while there are methods using spectrometers and spectrographs for detecting nickel in fats hardened by the catalytic hydrogenation process, testing of optical glass, the analysis and identification of dyes, etc.

The katharometer is an instrument devised for comparing the thermal conductivities of gases. Refractometers, viscometers, pyrometers, thermometers, elutriators, and other appliances are described under their respective headings; while centrifugal apparatus; gas, oil, steam, and air meters; hydraulic presses, elevators, agitators, autoclaves, conveyors, etc., are other items employed.

Vacuum-cleaning machines are used not only for the collection of dirt, but also for the recovery of valuable powders.

As to boilers and steam generation see Steam.

For low-pressure measurement, a new improved dial gauge of the diaphragm type is described in the *C.T.J.*, 1926, **78,** 418.

With respect to measuring there are many methods, and, amongst others, reference may be made to the "Kennedy" oil meter of the displacement type, consisting of a vertical cast-iron measuring cylinder

CHEMICAL PLANT (*Continued*)—

fitted with a metallic piston and cast-iron cover, of which each complete stroke actuated by the pressure of the oil corresponds to the displacement of a definite measured volume of oil.

The number of registered factories in Great Britain stood at 142,429, and the number of workshops 133,729 (H.M. Chief Inspector's Annual Report for 1924).

The employment of various types of machinery in relation to the investigation of delicate plant and animal products is the subject of an article by F. H. Carr (*Chem. and Ind.*, 1926, **45**, 874).

"Works Transport" is the subject of articles by H. J. Pooley (*Chem. and Ind.*, 1927, **46**, 1064) and by J. H. West (*Ibid.*, 1060).

Pneumatic transport plants may be of the "pressure" or "suction" types or a combination of both (see W. Cramp, *J.S.C.I.*, 1925, **44**, 207 T and 210 T). The transport of liquefied gases in cylinders is dealt with in the 4th Report of the Gas Cylinders Research Committee (see *C.T.J.*, 1930, **87**, 296, on the safety of welded containers).

Illustrations of various chemical plants will be found in *Ind. Chem.*, 1925, i., 227; 1926, ii., 21-28, and 517-539; 1930, vi., 453 and 485; and in all issues of that journal in 1931.

C. H. Butcher on "Common Constructional Materials for Chemical Plant" (*Ind. Chem.*, 1930, vi., facing pp. 444 and 445; 494 and 495) deals with cast iron, wrought iron and steel, copper, aluminium, lead (chemical quality); enamelled iron and steel, rubber, chemical stoneware, and fused silica, with particulars as to their applications.

John Varley and Co., of St. Helens, have published a series of true-scale models of the usual plant units, while the British Chemical Plant Manufacturers' Association (of 166, Piccadilly, London) publish an *Official Plant Directory*. See also *C.T.J.*, 1925, **77**, 350, and 1926, **78**, 287.

See also Account of the reconstructed plant of the Gas, Light, and Coke Co. at Bow Common Lane (*Chem. and Ind.*, 1930, **49**, 577); J. A. Watson on "Factory Process Returns and Plant Efficiency" (*Chem. and Ind.*, 1925, **44**, 101); a modern chemical plant concerned with the manufacture of a number of products (*C.T.J.*, 1930, **86**, 253-257); "Some Developments in 'Corrosion-Resisting Plant'" (*Ind. Chem.*, 1929, v., 487); article by A. Grounds (*Ibid.*, 1928, iv., 60); F. H. Rogers on "Factory Design and Floors" (*Chem. and Ind.*, 1928, **47**, 1011; *C.T.J.*, 1928, **83**, 315); F. H. Rogers on "Factory Lighting" (*C.T.J.*, 1928, **83**, 6); J. D. Pratt on "Chemical Plant Cleaning and Repair" (*Ind. Chem.*, 1931, vii., 246; and *Chem. and Ind.*, 1931, **50**, 489); "Chlorine Plant" (*Ind. Chem.*, 1930, vi., 487); "Chemical Plant Exhibition" (*Ind. Chem.*, 1931, vii., 274 and 320); Reports of the Building Research Board (H.M. Stationery Office); S. G. Ure (*Chem. and Ind.*, 1925, **44**, 1244); E. B. Partington on *Chemical Plumbing and Lead Burning* (Allen Liversidge, Ltd., Westminster); *Practical Transport Management*, by A. Hastie (Sir Isaac Pitman and Sons); *Transport Gear*, a catalogue book (Book 99), by Herbert Morris, Ltd., of Loughborough; *A Technical Chemist's Pocket-Book*, by R. Ensoll

CHEMICAL PLANT (*Continued*)—

(C. and F. N. Spon); and *Design and Arrangement of Chemical Plant,* by G. L. Weyman (Ernest Benn); Chemical Engineering, Chemical Works, Data Sheets, Heating, and Nomograms.

CHEMICAL PROCESS DEVELOPMENT—By A. D. Little (see *C.T.J.*, 1929, **85**, 52).

CHEMICAL REACTIONS—See Chemical Interactions and Reactions.

CHEMICAL SYMBOLS—See Elements, Chemical Compounds, Chemical Interactions, and Formulæ.

CHEMICAL TERMS—For fuller information respecting chemical terms, coefficients, critical constants, laws, etc., than is afforded by this Encyclopædia, see *Dictionary of Chemical Terms,* by J. F. Couch (D. Van Nostrand Company, N.Y.), and the *Chemical Age, Chemical Dictionary* (Ernest Benn, Ltd., London).

CHEMICAL THEORIES—See R. M. Caven's *Foundations of Chemical Theory* (Blackie and Son, Ltd., London and Glasgow).

CHEMICAL TRADE—See Trade.

CHEMICAL WARFARE—See "Some Echoes of Chemical Warfare" (*Ind. Chem.*, 1925, i., 137); also Gassing.

CHEMICAL WORKS—See description of one (*Ind. Chem.*, 1930, vi., 157); others are referred to under Chemical Plant. See also Annual Reports of the Alkali Act Inspectors (H.M. Stationery Office).

CHEMOTHERAPY—Specific treatment for infectious diseases by bacterial destruction or internal antisepsis, based partly on the artificial infection of animals with drugs and vaccines. (See H. H. Dale (*C.T.J.*, 1924, **75**, 154); H. H. Dale on "Viruses" (*Chem. and Ind.*, 1931, **50**, 827); paper by F. L. Pyman (*Chem. and Ind.*, 1930, **49**, 757) and J. Stuart (*Ibid.*, 1930, **49**, 800); *The Chemistry of Chemotherapy,* by G. M. Dyson (Ernest Benn); *Recent Advances in Chemotherapy,* by G. M. Findlay (J. and A. Churchill); Antiseptics, Bacteria, Biochemistry, Disinfectants and Toxins.)

CHENGAL RESIN—See Penak Resin.

CHENOPODIUM OIL—See Wormseed Oil.

CHERRY KERNEL OIL—See Jamieson and Gertler, *Analyst,* 1930, **55**, 761.

CHERT (**HORNSTONE**)—Massive silica (quartz) occurring in limestones of Palæozoic Age and in Mesozoic strata.

CHESSYLITE—See Copper (Azurite).

CHESTNUT EXTRACT—Prepared by leaching the bark of *Castanea sativa,* containing from 25 to 36 per cent. tannin; used for tanning and in dyeing and calico printing.

CHIA OIL—Expressed from the seeds of the Chia plant (*Salvia hispanica*), which grows in Mexico and yields from 24 to nearly 40 per cent.; sp. gr. 0·9338, i.v. 192·2, and sap. v. 192·2. It dries as quickly

CHIA OIL (*Continued*)—
as linseed oil, which it resembles in odour and taste, is of light amber colour, and is largely used as food and in compounding a particular drink. Further details of its composition are given by Baughman and Jamieson (*B.C.A.*, 1929, B, 902).

CHICORY—The root of the *Chicorium intybus,* a genus of Compositæ, used when roasted and ground to mix with (adulterate) coffee. A strong infusion is said to act as an aperient and sometimes as a diuretic, while the herbage is used as cattle food.

CHILE NITRE—See Caliche.

CHILE SALTPETRE—See Caliche.

CHINA (Porcelain, Pottery, Stoneware, etc.)—Articles made from bone phosphate and various classes of minerals, such as China clay (a product resulting from the gradual decomposition of rocks, including *felspar* and *granite*) in the nature of hydrous aluminium silicates. (See Clays, Porcelain, and Stoneware.)

CHINA CLAY—See Clays and Porcelain.

CHINA GRASS—See Ramie.

CHINA WOOD OIL—See Tung Oil.

CHINESE BLUE—A form of Prussian blue.

CHINESE INK—See Inks.

CHINESE RED—Lead Chromate.

CHINESE VEGETABLE TALLOW—See Vegetable Tallow.

CHINESE WAX—See Waxes.

"CHINESE WHITE"—Trade name for zinc oxide.

CHINESE WOOD OIL—See Tung Oil.

CHITIN—An organoplastic nitrogenous body, being a principal constituent of the dermatic envelope, and forming most of the hard parts of jointed-footed animals; also of the skeleton and tendon-like parts of articulate animals and insects such as silkworms. Various formulæ have been given to it, one being $C_9H_{15}NO_6$.

CHLOR-ACETIC ACID (CH_2Cl,CO_2H)—A deliquescent, crystalline, halogen substitution product of acetic acid, which melts at 62° C.; used as a corn and wart remover, and in the synthetic production of indigo.

CHLOR-ACETOPHENONE—A mixture of this substance with cyanogen chloride is used by the U.S. Public Health Service as a fumigant for the extermination of rats, mice, flies, and vermin in ships, etc., being less dangerous to human beings than chlor-acetophenone used alone.

CHLORAL ($CCl_3.CHO$)—A colourless oily liquid of sp. gr. 1·512 and b.p. 97·7° C.; soluble in alcohol and ether; prepared by the chlorination of absolute alcohol and subsequent treatment of the product with sulphuric acid, followed by distillation. The chloral alcoholate first formed is decomposed by the acid, and upon distillation ethyl chloride comes over first, then alcohol, and finally anhydrous chloral.

CHLORAL (*Continued*)—

Chloral hydrate ($CCl_3CH(OH)_2$) is a crystalline body of sp. gr. 1·1901, m.p. 57° C., and b.p. 97·5° C., prepared from chloral by mixing with a small quantity of water, when heat is evolved. It is readily soluble in water and alcohol, and is again resolved into chloral by the action of sulphuric acid. It is completely dissociated at 78° C.

Chloral urethane ($CCl_3.CH(OH).NH.CO_2C_2H_5$) is the source of a hypnotic known as "Somnal," being a soluble ethyl derivative.

Both chloral and the hydrate are used in medicine, the hydrate acting as a soporific.

CHLORAMINE-T or **TOLAMINE**—An antiseptic, being a derivative of toluene, capable of generating chlorine, and described as sodium-para-toluene-sulpho-chloramine, obtained from a by-product in the manufacture of saccharin. (See Chattaway (*J.C.S.*, 1905, **87**, 145), "Aktiven" and "Zauberin.")

CHLORAMINES—Amine compounds in which chlorine is directly combined with nitrogen, prepared by the action of hypochlorous acid on sulphonamides.

CHLORANIL (**Tetrachloro-quinone**) ($C_6Cl_4O_2$)—A substance prepared by the chlorination of quinone; it crystallizes in yellow plates, and is used as an oxidizing agent in making certain coal-tar dyes, also in a tanning process.

CHLORANILINES—Chlorinated derivatives of aniline, $C_6H_4ClNH_2$, $C_6H_3Cl_2NH_2$, and $C_6H_2Cl_3NH_2$. (See Mono-chlorbenzene.)

CHLORBENZENES—See Chlorobenzenes.

CHLORETHYLENES—See Solvents and Ethylene Dichloride.

CHLORHYDRINS (**Halohydrins**)—Glycerol esters of the halogen acids. (See Dichlorohydrin.)

Monochlorhydrin [$CH_2Cl.CH(OH)CH_2(OH)$] is a yellow thick liquid of sp. gr. 1·325 and b.p. 128° C., soluble in water and alcohol, made from glycerine and hydrochloric acid.

CHLORIDE OF LIME—See Calcium Compounds (Bleaching-Powder) and Chlorine.

CHLORINATION—The name given to any process by which chlorine is imported into the constitution of a substance; for example, lime is converted into bleaching-powder by the action of chlorine, and many additive and substitution products are derived from benzene hydrocarbons by the introduction of chlorine, hydrogen being replaced by chlorine in the last-named instances. Benzene hexachloride ($C_6H_6Cl_6$) is an additive substance produced by exposing benzene to chlorine gas for a prolonged period, etc. Methyl chloride (CH_3Cl) illustrates the chlorination act by which hydrogen is replaced by chlorine, and is obtained with other substances when chlorine is permitted to act on methane (marsh gas, CH_4). In the preparation of benzyl chloride from boiling toluene by the action of chlorine, the following interaction takes place: $C_7H_8 + Cl_2 = C_7H_7Cl + HCl$. The direct chlorination of solid and even powdered organic compounds is often attended with

CHLORINATION (*Continued*)—

difficulty, however good the agitation, by reason of the liability to overheating and irregular penetration, so that when possible it is better to deal with them in a melted state or in a state of solution, the application of heat being in many cases desirable or necessary.

The chlorination of indigo in order to obtain monochloro-indigo is facilitated by solution in nitro-benzol.

The chlorination of phenol can be directed to obtain a series of derivatives, including the ortho-chloro, para-chloro, tri-chloro, and tetra-chloro compounds.

A new and powerful chlorinating agent, as found by O. Silberrad, consists of sulphuryl chloride in admixture with aluminium-sulphur chloride, although in practice the sulphuryl chloride may be added to the subject substance previously mixed with a proportion of anhydrous aluminium chloride.

Light, and particularly the ultra-violet radiations, exercise great influence in many processes of chlorination.

CHLORINE (Cl) **and its Compounds**—Atomic weight, 35·457; sp. gr., 2·49; m.p., − 101·5° C. Chlorine is credited with three isotopes of the respective mass numbers 35, 37, and 39. (See O. Hönigschmid (*J. Amer. Chem. Soc.*, 1931, **53,** 3012) and Hettner and Böhme (*B.C.A.*, 1931, A, 543).) It is not found in nature in an uncombined state, but exists very extensively in combination with other substances, and most abundantly in the form of common salt—sodium chloride (NaCl). There are large deposits of salt in Cheshire, and it forms part of the well-known Stassfurt saline deposits (in Germany). Combined with hydrogen as hydrochloric acid (HCl), it is a natural constituent of the gastric juice of men and animals. In the form of salt it is always found present in sea-water in association with other salts; thus, the water of the English Channel contains 28·05 parts per 1,000. Common salt (rock salt) is mined to some extent in an impure state in the dry condition, but for the most part (being soluble in water) it is made by pumping water into the salt deposits, and crystallization resulting from evaporation of the brine thus prepared. (See Water, p. 970.)

Chlorine in gaseous form is manufactured on a large scale, and is employed chiefly in the preparation of chloride of lime (bleaching-powder), which is used for bleaching purposes and as a sanitary reagent. For this purpose it was at one time mostly made by the action of hydrochloric acid upon manganese dioxide ores:

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2.$$

In the Weldon process, the manganese is reprecipitated from the resulting manganese chloride liquor as calcium manganite ($CaO.2MnO_2$) or "Weldon mud," as it is called, by treatment with an excess of milk of lime and oxidation with a current of air at 55° to 60° C., ready for use over again. (See Manganese Oxides.)

In the "Deacon" process a mixture of hydrogen chloride (HCl) gas and air is exposed to the catalytic influence of cupric chloride distributed over a widely exposed surface of pumice-stone at a temperature of

CHLORINE (*Continued*)—

about 430° C., chlorine and water being finally produced as follows: $2HCl + O = H_2O + Cl_2$. This process produces weaker chlorine than the "Weldon" process, but eliminates the loss of calcium chloride.

Both the "Weldon" and the "Deacon" process have been practically superseded by the electrolytic method of manufacturing chlorine—that is, the direct electrolysis of a concentrated solution of common salt (brine)—in which the gaseous chlorine is evolved at the anode whilst sodium hydrate is produced at the cathode. The various electrolytic cells used in this process are described by J. B. C. Kershaw (*Ind. Chem.*, 1925, i., 283, and 1926, ii., 557). The gas made as described is stated to be disadvantageous for making bleaching-powder, inasmuch as being generated in a state of great activity it produces calcium chloride, but this difficulty is said to be overcome by first heating the gas to 800° C.

The daily production of chlorine in the United States is stated to be over 350 tons.

It is of a bright golden-yellow colour, and when sufficiently cooled it freezes to a yellow crystalline mass. It immediately passes into the gaseous state when liberated in the air, and has a very violent action on the linings of the mouth, nose, throat, and lungs, causing death when inhaled in serious quantity. In a liquefied state, and stored in iron cylinders, it was largely used in the Great War for "gassing" by reason of its corrosive and poisonous character.

Liquefied chlorine boils at $-33{\cdot}7^\circ$ C. under atmospheric pressure, and is used in the preparation of bleach-liquor, the manufacture of chlorides, dye-intermediates, and non-inflammable solvents. For further particulars respecting the transport, manufacture, and uses of liquid chlorine, see *C.T.J.*, 1926, **78,** 586; *Chem. and Ind.*, 1927, **46,** 230 and 253; and an illustration of a manufacturing plant (*Ind. Chem.*, 1930, vi., 487).

On account of its sterilizing value, chlorine as such, or in the form of bleaching-powder, is frequently used for the purification of water-supplies, the water of swimming-baths, also that of cooling waters of steam engines and turbines to prevent the growth of living organisms on the inside of the condenser pipes. It is also employed in the manufacture of potassium chlorate ($KClO_3$) (which is extensively used in match-making) and in the preparation of certain explosives, cellulose, rubber substitutes, chloral, chloroform, carbon tetrachloride, the chlorination of metals, etc.

Chlorine gas is of a greenish-yellow colour, and nearly two and a half times heavier than air. It is somewhat soluble in water, 1 volume of which at 10° C. absorbs 3·1 volumes of chlorine, forming a green solution. When strong chlorine water is cooled to nearly freezing-point, it deposits a crystalline hydrate ($Cl_2 6H_2O$) of unstable character.

Metallic copper in thin leaf form, metallic antimony in the form of powder, and sodium, all take fire and burn readily in chlorine gas, forming chlorides, although the gas itself is not inflammable. Similarly, a jet of hydrogen gas will burn in a vessel containing chlorine gas, thus

CHLORINE (*Continued*)—

producing hydrochloric acid in the form of white fumes which can be absorbed by water, and this process is now employed commercially.

Chlorine can be activated by electrical discharges, by ultra-violet light, and thermally, but the activated gas is unstable above 50° C. It combines with ozone to form chlorine monoxide: with sulphur to form sulphur monochloride, and with benzene in the dark to form $C_6H_6Cl_6$.

For a summary of an article dealing with the economics of chlorine by D. A. Pritchard see *C.T.J.*, 1926, **78**, 493; for its applications in organic chemistry see J. T. Conroy (*Ibid.*, 531); and with respect to the kinetics of chlorine bleaching see J. J. Weiss (*B.C.A.*, 1931, A, 572).

Hydrochloric Acid, or hydrogen chloride (HCl), is one of the most important compounds of chlorine. The two gases hydrogen and chlorine may be made to combine as described above, but do not combine when mixed together in the dark, although in sunlight or electric light they combine with explosive violence. (See R. G. W. Norrish, *J.C.S.*, cxxvii., 2316.) The acid can be manufactured by the direct combustion method (see *Ind. Chem.*, 1930, vi., 489) and easily prepared, amongst other methods, by the action of strong sulphuric acid upon common salt (in mechanical furnaces which have now replaced the old hand-operated ones) as represented by the equation: $2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$. That is to say, sodium sulphate and hydrochloric acid are produced, and the acid can be distilled over from the mixture in the form of gas and condensed in water, thus furnishing a solution of the acid. This condensation is practically effected by the action of water percolating down towers or stacks packed with broken coke, up which it is led. (See "Zieren" Condensation Towers.)

The "Zahn" process of making the acid together with sodium sulphate is based upon the interaction of salt and sulphuric acid with a molten liquid mass of sodium bisulphate. There is an Italian industrial process for making it by passing steam and chlorine gas over carbon heated in a refractory furnace to 600° C., the two reactions which occur being as follows:

$$C + H_2O + Cl_2 = CO + 2HCl \text{ and } CO + H_2O + Cl_2 = CO_2 + 2HCl.$$

In its gaseous form the acid is colourless, and possesses a pungent, irritating character. It is soluble in water, 1 volume of which at 0° C. and under ordinary atmospheric pressure dissolves 503 volumes. A commercial form known as "Muriatic Tower Salts" is marketed of 28° Tw. strength. The ordinary commercial hydrochloric acid is an aqueous solution of from 28 to 32 per cent. strength, seldom pure, whereas the synthetic acid now made by the direct combination of hydrogen and chlorine is water white, of great purity, and can be had up to 40 per cent. HCl content. In pure liquefied form it boils at $-83°$ C. under atmospheric pressure.

Hydrochloric acid finds extensive use in the textile, galvanizing, chrome-tanning industries, wire-drawing, metal-etching, soldering, the reduction of aromatic nitro-compounds, the manufacture of dyestuffs, etc.

CHLORINE (*Continued*)—

It decomposes the oxides and carbonates of the alkaline and other metals, the chloride of the base being produced in each case.

Its storage and transport other than in glass carboys has proved a matter of difficulty, but large wooden vessels lined with soft rubber have been used successfully, and a pitch-binder named "Prodorite" is a good lining material. Ebonite-lined steel tanks are also used for transport, and vessels made of Staffordshire blue-brick cemented together with "Prodorite" can be used for storage.

Three chlorine oxides are known— viz., Cl_2O, ClO_2, and Cl_2O_7.

Hypochlorous Acid ($HClO$) is only known apart from its compounds, in association with water, in which it is soluble, the solution being yellowish in colour and having a chlorous odour. It can be made by a number of processes, notably by the action of any dilute mineral acid, such as hydrochloric acid, upon a soluble hypochlorite such as a solution of bleaching-powder. Strong solutions of the acid are unstable and apt to decompose with violence, but dilute ones are more stable and used as powerful oxidizing and bleaching agents.

Sodium Hypochlorite ($NaClO$) in solution is made by electrolyzing a cold dilute solution of common salt, also by reaction between bleaching-powder and sodium carbonate in solution or by the direct chlorination of a solution of caustic soda or sodium carbonate. It can be obtained in greenish-yellow, needle-shaped crystalline form by concentration of a solution *in vacuo* at a low temperature; m.p. of $24{\cdot}5 \pm 0{\cdot}5°$, decomposing below 25°. Several hydrates are known, and that represented by $NaClO,H_2O$ is liable to explode when warmed or placed in contact with organic matter. It is used as a sanitary reagent, and more extensively for oxidizing and bleaching purposes. (See T. L. Kolkin (*Ind. Chem.*, 1932, viii. 97).)

Chloric Acid ($HClO_3$) can be prepared by the action of dilute sulphuric acid upon barium chlorate, but it is only known in association with water, as a stronger solution than 80 per cent. decomposes upon heating into chlorine and water. It is a powerful oxidant, wood and paper being liable to combustion when a strong solution of it is dropped upon them.

Perchloric Acid ($HClO_4$) can be prepared by the action (under reduced pressure) of strong sulphuric acid upon barium or potassium perchlorate at from 140° C. and upwards, and, when pure, is a colourless volatile fuming liquid of sp. gr. 1·782 at 15° C., possessing very powerful oxidizing properties. Hydrochloric acid can be in large measure converted electrolytically into perchloric acid and perchlorates made therefrom. Many of the perchlorates are soluble bodies. The lead salt is of use for electro-plating purposes, and the magnesium perchlorate finds use as a drying agent.

According to Kuff and Krug, chlorine trifluoride (ClF_3) has been prepared as a colourless gas which condenses to a pale green liquid of b.p. 11° C.; the solid form is colourless and of m.p. $-83°$ C. (See *B.C.A.*, 1930, A, 878.)

CHLORITE (**Ripidolite**)—A mineral, hydrated double silicate of aluminium and magnesium coloured green with iron, often found in association with garnet, quartz, and calcite; crystal systems, Nos. 3 and 5, and sp. gr. 2·6 to 2·8.

A white chlorite from Madagascar has a composition approximating to $3Al_2O_3,12MgO,7SiO_2,10H_2O$ (J. Orcel).

CHLOROBENZENES (**Chlorbenzenes**)—Most of the chlorinated derivatives can be obtained in succession up to C_6Cl_6. The mono-compound C_6H_5Cl is obtained by direct action of chlorine upon benzene in presence of a small aluminium-mercury couple acting as a carrier or in the presence of molybdenum chloride. This liquid has a sp. gr. 1·1064 and b.p. 132° C., is soluble in alcohol and ether, and is used in the dyestuffs industry and manufacture of picric acid, etc. The ortho- and para-chlorobenzenes are used as solvents and in preparing dichloranilines. (See *Ind. Chem.*, 1925, i., 342.)

"CHLORODYNE"—A pharmaceutical compound containing prussic acid, morphia, chloroform, and hemp, having properties of an opiate and antispasmodic.

CHLOROFORM ($CHCl_3$)—A somewhat unstable halogen substitution product constituting a valuable, volatile, anæsthetic liquid, prepared from acetone, alcohol, or acetaldehyde by the action of chloride of lime and water followed by distillation. Its stability is increased by the addition of about 2 per cent. ethyl alcohol. In another method of preparation ethyl alcohol is saturated with chlorine and the chlorinated liquid is then treated with calcium hydroxide mixed with a little bleaching-powder. It is a useful solvent of fats and other substances, boils at 61·2° C., has a sp. gr. of 1·499, and is soluble in alcohol and ether.

CHLOROMETHANE—See Methyl Chloride.

CHLORONOME—An apparatus for the use of chlorine gas from cylinders.

CHLOROPHENOLS—*o*- and *p*-chlorophenols are formed by action of chlorine upon phenol, and the *m*- compound by reduction and diazotization of the haloid nitro-benzenes; all the five hydrogen atoms of phenol can be replaced by chlorine (and bromine).

p-Chlorophenol is colourless, crystalline, m.p. 41° C., and b.p. 218° C. The *o*- compound is also crystalline, m.p. 7° C. and b.p. 177° C., while the *m*- compound is a colourless oil of b.p. 214° C.

CHLOROPHYLL—See Noack and Kiessling on its formation (*B.C.A.*, 1931, A, 634); Photocatalysis, Plant Colouring Matters, and Vegetation.

CHLOROPICRIN ($C.Cl_3NO_2$)—A heavy suffocating liquid, made from picric acid by the action of bleaching-powder or chlorine. It was used as a poison gas in the Great War, and has been applied as a fumigant for cereal products and for killing silkworm cocoons and mill and household insects when mixed with an equal volume of carbon tetrachloride and applied by an atomizer. (See R. N. Chapman, *J. Agric. Res.*, 1925, **31**, 745-760.)

CHLOROPLASTS—See Plant Colouring Matters.

"CHLOROS"—A proprietary disinfectant containing sodium hypochlorite.

CHLORO-SULPHONIC ACID ($HClSO_3$)—A brown, oily, corrosive liquid sp. gr. 1·784, soluble in water, made by action of chlorine on cooled sulphuric acid; used in making saccharin and smoke screens, etc.

CHOCOLATE—See book on its chemistry by H. R. Jensen (J. and A. Churchill); *Modern Methods of Cocoa and Chocolate Manufacture,* by H. W. Bywaters (J. and A. Churchill); and Cacao.

CHOKE-DAMP (**Black-Damp**)—A mixture of carbon dioxide and other poisonous gases met with in coal-workings, particularly after explosions.

CHOLESTEROL (**Cholesterine**) ($C_{27}H_{46}O$)—A white, inodorous substance which crystallizes in beautiful pearly plates from aqueous alcohol with one molecule of water, which it loses at 100° C. Great difficulty is observed in preparing cholesterol absolutely free from associated sterols, but when quite pure it is not susceptible of activation by exposure to ultra-violet rays. (See Rosenheim and Webster, *Biochem. Journ.*, **20,** No. 3, 1926, and **21,** No. 1, 1927, and compare R. Schönheimer on the "Migration of Hydrogen in Cholesterol," *B.C.A.*, 1930, A, 1577.) It is insoluble in water, but soluble in ether and hot alcohol, and melts at 145° C. It enters into the composition of gall-stones, the human bile, brain and nerve substance, being present in bile to the extent of about 0·25 per cent., in brain-matter to about 10 per cent., calculated upon the total dry solid parts, in egg-yolk and many animal fats and oils. It is regarded as an unsaturated secondary alcohol, and can be sublimed without decomposition at about 200° or 300° C. *in vacuo*. In certain solvents, cholesterol is said to be decomposed by exposure to X-radiation (see Bachem and MacFate, *B.C.A.*, 1929, A, 1249). An amorphous combination formulated as $C_{27}H_{46}O$, $SbCl_5$, soluble in chloroform, has been described (Steinle and Kahlenberg, *B.C.A.*, 1926, A, 633), and a camphorate formulated as $C_8H_{14}(CO_2C_{27}H_{45})_2$ by E. Montignie (*B.C.A.*, 1929, B, 312). (See also De Conna and Finalli on "Cholesterol of Buffalo Butter" (*B.C.A.*, 1930, B, 619); Sterols and Vitamins.)

CHOLIC ACID—See Taurocholic Acid and Bile.

CHOLINE ($C_5H_{15}NO_2$)—A basic substance obtainable from brain-matter and bile which yields muscarine under certain conditions of oxidation.

CHONDRIN—An albuminous substance resembling gelatine, produced by boiling certain animal tissues, such as cartilages, with water, in which it is soluble. It can be converted into normal gelatin and mucin.

CHONDRUS—See Sea-weeds.

CHROMATES—See Chromium Compounds, Chrome Yellows, and article on the production of soluble chromates by A. J. Sofianopoulos (*J.S.C.I.*, 1930, **49,** 279 T).

CHROMATOMETER—An instrument for determining degrees of colour.

CHROME ALUM—See Alum (Chrome).

"CHROME GREEN"—Trade name for chromium oxide; used also in respect of a mixture of Prussian blue and lead chromate.

CHROME IRON ORE (**Chromite**)—See Chromium.

"CHROME RED"—Also known as "American Vermilion," "Persian Red," and "Derby Red," has the composition of the basic character represented by Pb_2CrO_5, and results from interaction between lead chromate with sodium hydroxide or normal potassium chromate and lead chromate; or, again, by precipitation of lead chromate in presence of excess of basic lead acetate followed by heating.

CHROME SALT-CAKE—An impure yellowish or greenish sodium sulphate obtained as a by-product in making potassium dichromate.

"CHROME YELLOWS"—Essentially lead chromate ($PbCrO_4$). They can be prepared from any soluble salt of chromium and one of lead, or by admixture with lead sulphate, and are classed as "Chinese red," "Acetate Chrome," "Chloride Chrome," "Nitrate Chrome," and so forth. They vary greatly in shade (from bright citron yellow to orange), in bulk (density), and oil absorptive power.

The lighter shades are made by addition of small proportions of sulphuric, tartaric, or citric acid, and the darker ones by that of caustic soda, to the normal chrome, which is the palest pure middle chrome. The zinc chromes are paler and more permanent to light, but of less covering power.

According to Wagner and Keidel (*B.C.A.*, 1926, B, 500), the state of dispersion in chrome yellows is dependent on their solubility in the mother liquor, and that in turn is controlled by the salts used and the practical conditions of manufacture, including concentration in particular. An account of their manufacture is given by J. Remington (*Ind. Chem.*, 1929, v., 292).

"CHROMETAN"—See Tanning.

CHROMIC ACID—See Chromium Compounds.

CHROMITE—A mineral of mixed oxides of iron and chromium, of crystal system, No. 1, and sp. gr. 4·3 to 4·6. In the pure form as FeO,Cr_2O_3 it is stated to occur only in meteorites, the mineral forms varying in composition in respect of the two oxides. (See L. W. Fisher, *B.C.A.*, 1930, A, 570; also Chromium.)

CHROMIUM (Cr) **and its Compounds**—Atomic weight, 52·04, and alleged to exhibit several isotopes; sp. gr., 6·92; the m.p. hitherto assigned to it has been 1,615° C., but a more recent determination gives 1,920° C. (Smithells and Williams, *Nature*, 1929, **124**, 617). Chromium occurs in nature in combination in a number of minerals, including chrome iron ore or *chromite* (Cr_2O_3FeO)—the main source from which chromium and its compounds are made, and which yields from 48 to 52·75 per cent. of the oxide. Large supplies come from Asia Minor, Greece, India, Russia, New Caledonia, U.S.A., Canada, and in particular from Rhodesia, which furnishes from half to three-quarters of the world's supply; while considerable quantities are mined in California and Oregon (U.S.A.), in Portuguese Africa, and French Oceania, and there are good deposits in Cuba. Chromium also occurs in the forms of lead

CHROMIUM (*Continued*)—
chromate or *crocoisite* ($PbCrO_4$) and *chrome ochre* (Cr_2O_3). Chromite is used, among other applications, in the manufacture of chromite bricks for lining metallurgical furnaces.

Chromium is a steel-grey metal, hard as corundum, and is employed in coating copper and in making nickel-chromium-iron alloys of heat- and acid-resisting character; also for the purpose of imparting hardness and tenacity to steel used for making tyres, springs, axles, and armour-plate, by incorporation of from 0·5 to 3 per cent. Chromium plating on elastic metal supports gives valuable help in the construction of jets, rollers, journals, cams, pistons, cylinders, etc. Chromium plating can be highly polished and nickel-plated, and it resists corrosion better than when unpolished. Coatings can be obtained by electro-deposition up to $\frac{1}{8}$ inch in thickness; thus, in undesirable cases, making it unnecessary to use nickel as an underlayer. (See *C.T.J.*, 1927, **81,** 152; *Ibid.,* 1930, **86,** 165, and **87,** 371; S. Wernick on chromium plating as a corrosion preventive (*Ind. Chem.,* 1929, v., 524); E. J. Dobbs (*J.S.C.I.,* 1930, **49,** 161 T); Pfanhauser and Eissner (*B.C.A.,* 1932, B, 150); F. M. Becket on "High Chromium Steels" (*Chem. and Ind.,* 1932, **51,** 49); characteristics of the chromium and chromium-nickel steels, by W. H. Hatfield (*Ind. Chem.*, 1925, i., 64, and 1926, ii., 11.)

The risks of poisoning by the use of chromium salts in lithography, tanning, plating, etc., particularly when the skin of the workers is broken, is viewed seriously, and proposed regulations for the prevention of ill-effects on persons engaged in the chromium plating industry is the subject of an article (*C.T.J.,* 1930, **87,** 133). (See also Alloys, Ferro-Alloys, and Rustless Steel.)

The metal can be prepared by reducing chromic oxide at 1,500° C. in perfectly dry hydrogen, and is manufactured from its oxide by intensely heating a mixture of it with powdered metallic aluminium, which combines with the oxygen to form alumina (Al_2O_3), metallic chromium being set free in a molten condition. (See "Corubin.")

There are two oxides, Cr_2O_3 (chrome green) and CrO_3, the former of which, known as chromium sesquioxide, is used in ceramics and as a green pigment. The other (chromic anhydride or trioxide) constitutes the colouring matter of the ruby, and can be obtained in red, needle-shaped crystals from sodium or potassium dichromate by treatment with excess of sulphuric acid of from 66 to 84 per cent. strength, the crystals separating out on cooling. (See C. Arnold, *B.C.A.*, 1931, B, 157.) It is also produced from calcium chromate, as obtained from chrome iron ore by treatment with sulphuric acid. This oxide when heated to 250° C. gives off oxygen, and is converted into the lower oxide ($2CrO_3 = Cr_2O_3 + 3O$). It is a powerful oxidant, and when dissolved in water is supposed to produce chromic acid (H_2CrO_4), which is used as a bath for electro-plating iron and steel with chromium.

Potassium Chromate (K_2CrO_4) is a yellow crystalline body, soluble in water, used in dyeing and ink making; whilst the dichromate ($K_2Cr_2O_7$), which melts at $398{\cdot}4° \pm 0{\cdot}5°$ C., is also soluble in water,

CHROMIUM (*Continued*)—

crystallizes in red prisms. It is manufactured on a large scale, not merely on account of its uses in the match industry, tanning, bleaching, dyeing, and as an oxidizing agent, but also (in association with sulphuric acid) for the removal of red stains on brass, and chiefly in respect of the preparation of various well-known chrome pigments, including "chrome yellow," or lead chromate ($PbCrO_4$). It also finds some use in photography, as when a film of gelatin is treated with a solution of that substance it is rendered insoluble by the chemical change that ensues. (See "Chrome Yellows.")

Potassium Dichromate is manufactured by roasting chrome iron ore with potassium carbonate and lime, followed by lixiviation with a hot solution of potassium sulphate: this reacts with the calcium chromate to form calcium sulphate and potassium chromate, and then treatment with sulphuric acid converts the potassium chromate into the dichromate, which can be crystallized out. It is also manufactured, among other processes, by reaction between sodium dichromate and potassium chloride, followed by crystallization, and is used in photography and the tanning industry. (See J. B. Robertson, *J.S.C.I.*, 1924, **43,** 334 T.)

Sodium Chromate ($Na_2CrO_4 10H_2O$) is a yellow efflorescent salt, m.p. 19·92° C., soluble in water, used in ink-making, tanning, and dyeing, made as stated under Sodium Dichromate.

Sodium peroxide is used commercially to oxidize chromium salts (such as chromic oxide) into chromates by fusion.

Sodium Dichromate ($Na_2Cr_2O_7,2H_2O$), a yellow crystalline salt, soluble in water, is manufactured by fluxing chrome iron ore with lime and soda ash, and conversion of the sodium chromate so obtained, by the action of sulphuric acid, followed by crystallization ($2Na_2CrO_4 + H_2SO_4 = Na_2Cr_2O_7 + Na_2SO_4 + H_2O$). It is cheaper than the corresponding potassium compound, but has the disadvantage of being very hygroscopic. It is used industrially for the same applications as the potassium salt, and the ammonium dichromate is used as a mordant for dyeing. (See L. L. Popov, *B.C.A.*, 1926, B, 946; and Chrome Salt-Cake.)

Chromium Chloride ($CrCl_3$)—A nearly insoluble, violet, crystalline body; its hydrate ($CrCl_3 6H_2O$) is soluble in water, and used as a mordant.

Chromium Phosphate ($CrPO_4$) (Plessy's green) is insoluble in water and used as a pigment.

Chromium Sulphate ($Cr_2(SO_4)_3$) and its hydrate ($Cr_2(SO_4)_3 15H_2O$), the former being insoluble, but the latter soluble in water, are both used in the textile trades.

Chromium-Potassium Sulphate ($K_2SO_4,Cr_2(SO_4)_3.24H_2O$) is a violet-red crystalline salt, soluble in water, used as a chrome tan liquor and in the textile industry. (See Alum Chrome.)

Chromium Acetate ($Cr(C_2H_3O_2)_3.H_2O$) is a greenish powder soluble in water, used in dyeing and calico printing.

CHROMIUM (*Continued*)—

Chromium Fluoride ($CrF_3 4H_2O$) is a green crystalline substance used as a printing, dyeing, and colouring material.

Chromium Borate is used as a pigment in calico printing.

Chromium Formate, made by interaction between sodium dichromate, sodium disulphite, and formic acid, is used in the calico-printing industry.

Other chromium compounds include chromous chloride ($CrCl_2$) and chromous sulphate ($CrSO_4.7H_2O$), several hydroxides, one of which —chromic hydroxide ($Cr(OH)_3$)—is obtained as a gelatinous precipitate by adding sodium hydroxide solution to a chromium salt solution. (See article on Chrome Green Pigments (*C.T.J.*, 1927, **80,** 529), and F. W. Aston on "Constitution of Chromium" (*Nature,* 1930, **126,** 200), and Tanning.)

CHROMOGENS—The parent group of dyestuffs formed by substitution of chromophores in hydrocarbons, and when, in addition, a strong basic or acid group (such as NH_2 or $.SO._2.OH$) is also present, dyes are obtained. (See Dyes.)

CHROMOPHORES—The particular atomic groupings characteristic of coloured organic compounds, such as $.N:N$ and NO_2—for example, azobenzene ($C_6H_5:N:N.C_6H_5$), which is a chromogen containing the chromophore—N : N—. (See Dyes and Chromogens.)

CHROMOPLASTS—The chromo-coloured matters in plant cells. (See Plant Colouring Matters.)

CHRYSAMINE—A substantive yellow coal-tar dye of the "Congo" class used in the leather and textile trades; prepared from salicylic acid and benzidine.

CHRYSAROBIN—See Chrysophanic Acid.

CHRYSAZIN (Dihydroxy-anthraquinone, 1 : 8) ($C_{14}H_6O_2OH)_2$)—A reddish-brown, crystalline body, m.p. 191° C.; soluble in alcohol, used in dyestuffs.

CHRYSENE ($C_{18}H_{12}$)—A white, crystalline hydrocarbon, m.p. 250° C., b.p. 448° C., contained in the coal-tar distillate which comes over above 360° C., resembling anthracene in general properties.

CHRYSOBERYL—A mineral gem, of crystal system, No. 4, and sp. gr. 3·5 to 3·8, consisting of the oxides of aluminium and beryllium (Al_2O_3BeO).

CHRYSOIDINE—An orange-red colour which dyes silk and wool directly. It is a hydrochloride of 2 : 4-diamido-azobenzene ($C_6H_5.N:N.C_6H_3(NH_2)_2.HCl[N_2:(NH_2)_2 = 1:2:4]$), slightly soluble in water.

CHRYSOLITE ($2(MgFe)O.SiO_2$)—A mineral double silicate of magnesium and iron occurring in Egypt, Brazil, Russia, etc.; crystal system, No. 4, and sp. gr. 3·3 to 3·5. Chrysolite asbestos is stated to contain water in combination and is hygroscopic; it loses this water at high temperatures attended with loss of fibre strength, but this is regained upon exposure to the air.

CHRYSOPHANIC ACID (Chrysarobin) ($C_{30}H_{26}O_7$)—Prepared from Araroba (Goa powder), deposited in the wood of *Vouacapoua araroba,* by extraction with hot chloroform, and is also a constituent of senna. It is soluble in water, alcohol, and ether, melts at 157° C., and is used in unction form in cases of *alopecia,* ringworm, and other skin affections. Respecting the composition of chrysarobin, see R. Eder and F. Hausen, *J.C.S.,* 1925, p. 1160 T.

CHRYSOPHRASE—A variety of chalcedony.

CHRYSOTILE (Peridot, Fibrous Serpentine)—Natural crystals (crystal system, No. 4) of *olivine* (a magnesium silicate, $H_4Mg_3Si_2O_9$), found in basalt and lavas. (See Asbestos.)

CHYLE—The digested alkaline fluid resulting from the conversion of chyme by action of the biliary and pancreatic juices, and thus prepared ready for absorption by the lacteals of the intestines for conversion into blood.

CHYME—The stomach-digested food before it is acted upon by the bile and pancreatic juice.

CIDER—Fermented juice of apples, containing from 5 to 9 per cent. alcohol. Its characteristics are described by W. H. Bufton (*Analyst,* 1927, **52,** 649). See also grade designations and characteristics (Agricultural Produce Grading and Marking Act, 1928 (H.M. Stationery Office).

"CIMENT FONDU"—See Cement.

CIMOLITE—A mineral hydrous aluminium silicate occurring in the island of Argentiera, Bohemia, and Russia; of sp. gr. 2·18 to 2·30, used as an absorbent. (See Fuller's Earth.)

CINCHONA (Peruvian Bark, Loxa Bark, Red Peruvian Bark, etc.)—The bark of the stems and branches of various species of *cinchona* and other genera of the *Rubiaceæ* order, growing in the Cordilleras and elsewhere between the latitudes 10° N. and 19° S. The natural cinchona trees occur on the slopes of the Andes from Colombia down to Bolivia through Ecuador and Peru, but the chief cultivated supplies are obtained from Java and India. The output of quinine from the Indian factories for the three years 1916-18 reached an average of 64,000 lbs. per annum. Some thirty important bases or alkaloids are contained in these barks, including quinine ($C_{20}H_{24}N_2O_2.3H_2O$) (about 3 per cent.), cinchonine ($C_{19}H_{22}N_2O$), quinidine ($C_{20}H_{24}N_2O_2$), and cinchonidine ($C_{19}H_{22}N_2O$), the two last named being respectively regarded as probably stereoisomeric with the two former. These alkaloids exist in the bark chiefly as quinates and cinchotannates with quinic acid ($C_7H_{12}O_6$) and cinchotannic acid ($C_{14}H_{16}O_9$).

Quinine ($C_{20}H_{24}N_2O_2,3H_2O$) is a white, crystalline alkaloid of m.p. 67° C., and, in the anhydrous form, of m.p. 177° C.; soluble in alcohol and ether, and intensely bitter. The sulphate and chloride are both used as febrifuges and otherwise in medicine; also the acetate, benzoate,

CINCHONA (*Continued*)—
phosphate, salicylate, tartrate, tannate, citrate, and glycerophosphate. The sulphate, $(C_{20}H_{24}N_2O_2)H_2SO_4 7\frac{1}{2}H_2O$, is a white, crystalline powder soluble in water to the extent of 1 in 350 parts, has a bitter taste, and in solution exhibits a strong fluorescence.

Galenical preparations are made chiefly from "red cinchona bark" —*Cinchona succirubra* (Java)—which sometimes contains as much as 10 per cent. total alkaloids.

Ninety per cent. of the world's production of quinine is obtained from Java cinchona bark, and only 4 per cent. from India, although the resources of the British Empire are stated to be sufficient, if utilized, to be independent of Holland.

One method of preparing quinine consists in mixing the finely ground bark with powdered lime, extracting the mixture with hot high-boiling paraffin oil, and, after filtration, shaking the filtrate with dilute sulphuric acid. The acid solution is then neutralized with sodium carbonate solution, and upon cooling, the quinine sulphate crystallizes out, and from this the alkaloid can be obtained by treatment with ammonia.

Cinchonine is a white, crystalline body, slightly soluble in water, alcohol, and ether, and m.p. of 264° C., from which quinoline may be prepared. The hydrochloride, nitrate, and sulphate are all soluble in water and alcohol.

The sulphate $(2(C_{19}H_{22}ON_2),H_2SO_4)$ is used for the determination of tannin in various materials, giving the true amount lower than that of the hide-powder process, which gives the percentage of all materials removable by that reagent.

Conchinine (**Quinidine**), m.p. 171·5° C.; stereo-isomeric with quinine; colourless, crystalline, efflorescent, soluble in alcohol and ether, and possesses moth-propelling properties. (See *C.T.J.*, 1927, **81**, 391.)

Cinchonidine (m.p. 206·5° C.), white, crystalline; soluble in alcohol.

All the antifebrile barks are used medicinally in the form of tinctures and infusions, on account of their valuable febrifugal and tonic properties, as are also those of the separated alkaloids and their sulphates, whilst the exhausted barks are used in the tanning industry. From recent investigations it would appear that quinine and quinidine are more efficient as anti-malarial agents than cinchonine, while the value of conchonidine is still uncertain (T. A. Henry, *Chem. and Ind.*, 1930, **49**, 786). Some quinine derivates exhibit high bactericidal properties. (See D. Howard on "Cinchona Barks and their Cultivation" (*J.S.C.I.*, 1906, p. 97); "Some Notes on the Cinchona Industry," by B. F. Howard (Inst. of Chemistry lecture, 1930); and Quinoline.)

CINEOL ($C_{10}H_{18}O$), otherwise known as cineole and eucalyptol, is found in many essential oils, and is the predominating constituent of the oils of cardamon, cajuput, wormseed, and *Eucalyptus globulus*. It is derived from terpin hydrate ($C_{10}H_{22}O_3$) by dehydration, and is a colourless liquid of characteristic camphoraceous odour, soluble in

CINEOL (*Continued*)—

ether, with a sp. gr. of 0·930, b.p. 176° C., ref. ind. at 20° C. about 1·4581, and m.p. +1° C. (See *Analyst*, 1927, **52**, 276 and 279).

CINNABAR—Native sulphide of mercury (HgS), of crystal system, No. 3, and sp. gr. about 9·0; used as a pigment; mines occur in Spain, California, Germany, China, Japan, and elsewhere.

CINNAMIC ACID ($C_9H_8O_2$ or $C_6H_5.CH:CH.CO_2H$)—A white, crystalline derivative of benzene found present in Peru and Tolu balsams, and liquid storax. It can be prepared by the oxidation of benzalacetone with sodium hypochlorite, but a better yield is secured by use of a method the details of which will be found in *C.T.J.*, 1929, **85,** 8. It is soluble in alcohol, ether, and hot water, and yields benzoic acid upon oxidation; is monobasic; m.p. 133° C., b.p. 300° C; forms a large variety of crystallizable salts, and is used in perfumery. When fused with potash, it splits up into benzoic and acetic acids. (See Balsams (Storax).)

CINNAMIC ALCOHOL (**Styrone or Cinnamyl Alcohol**) ($C_6H_5.CH:CH:CH_2OH$) crystallizes in white needles, is soluble in alcohol and ether, has an odour like that of hyacinths, and is used in perfumery. It occurs as cinnamic ester (styracin, cinnamyl cinnamate, $C_{18}H_{16}O_2=C_9H_7O(C_9H_9)O$) in storax, and is prepared from that substance by the action of potassium hydroxide, followed by distillation. It can also be prepared from cassia oil. (See *J.C.S. Abs.*, cxxvi., I, 1308; and paper by J. McLang, *C.T.J.*, 1926, **79,** 496.) Its sp. gr. is 1·0397 and b.p. 257° C. By oxidation it yields cinnamic acid, and when the oxidation is more vigorous, benzoic acid. (See Balsams, Cassia Oil, Storax, and Styrene.)

CINNAMIC ALDEHYDE (C_9H_8O or $C_6H_5CH:CH.CHO$)—An aromatic oily body of sp. gr. 1·054, ref. ind. 1·6195, and b.p. 253° C., forming the chief constituent of cinnamon oil (from *Persea cinnamomum*); soluble in alcohol and ether, and used in perfumery.

CINNAMON—A well-known spice, being the dried inner bark of trees of the genus *cinnamomum* which grow in Ceylon. It yields from ½ to 1·25 per cent. of the essential oil of cinnamon, which is prepared from it by distillation with salt water, and contains from 58 to 80 per cent. aldehyde, principally cinnamic aldehyde (C_9H_8O), and eugenol. The oil possesses an aromatic pleasant odour and taste, and is used in perfumery, also for flavouring and medicinally as a stimulant. It is soluble in alcohol, ether, etc.; has a sp. gr. 0·995 to 1·04 at 15° C., ref. ind. 1·57 to 1·60 at 20° C., and a rotation of 0° to −1°.

Inferior barks come from Java, Brazil, South India, and the West Indies.

Cinnamon *leaf* oil is distilled from the leaves of the *Cinnamomum zeylanicum,* the yield being from 1·5 to 2 per cent. It is pale yellow, has a characteristic spicy odour, contains from 70 to 75 per cent. eugenol and about 3 per cent. cinnamic aldehyde; sp. gr. 0·995 to 1·044 at 20° C., ref. ind. 1·535 at 20° C., opt. rot. 0° 5′ to −1°, and is

CINNAMON (*Continued*)—
similarly used. There is a growing demand for this oil as a source of vanillin. (See Cassia Oil and Vanilla.)

CIRCULATION APPARATUS—For liquids and vapours. (See Hughesdon, Robertson, and Read, *J.S.C.I.*, 1929, **48,** 263 T.)

CITRAL (or Geranial) ($C_{10}H_{16}O$)—An aldehydic body (stated to consist of two isomerides) found in the oils of lemon, oranges, verbena, and lemon-grass, the last named of which contains from 70 to 80 per cent. It is a colourless oil, used in perfumery, and as a source of ionine; it boils at 119° C. (2 mm.); may be obtained by the oxidation of geraniol, which is its corresponding alcohol ($C_{10}H_{18}O$), and forms the chief constituent of Indian geranium oil. (See Geraniol and Irone.)

CITRENE—See Terpenes.

CITRIC ACID ($C_6H_8O_7$ or $CO_2H.CH_2.C(OH)CO_2H.CH_2.CO_2H$)—Occurs naturally in many fruits, including tomatoes, pineapples, lemons, citrons, oranges, red bilberries, strawberries, raspberries, and in association with malic acid in gooseberries. It is industrially prepared from juice of the *Citrus medica* and other citrous order fruits, being mainly produced in Sicily and adjacent Italian mainland provinces. It is also found as calcium citrate in potatoes, beetroot, etc., but lemon-juice and lime-juice are the materials from which it is usually made. Certain enzymes are capable of building up the acid in citrous fruits, and it is stated to be produced by the action of *A. fumaricus* on 15 per cent. solutions of calcium gluconate. (See Glucose.)

It is now manufactured on an extensive scale in the U.S.A. by the fermentation of sucrose solution or molasses containing some nutrient salts, using the spores of a special strain of the mould *Aspergillus niger*. The citric acid can be precipitated as calcium or barium citrate and the acid worked up from the product. In a direct process worked out by C. Crotto, the lemon-juice is concentrated to the consistency of a paste and then macerated with acetone of twice its weight, after which it is filtered from the albuminous and other insoluble material and the filtrate mixed with half its weight of distilled water, in which the citric acid dissolves, while the acetone is separated and recovered.

When pure it crystallizes in association with water ($C_6H_8O_7.H_2O$) in large, colourless, rhombic prisms, of m.p. 153° C. readily soluble in water. Citric acid and its salts are used in medicine, in the preparation of summer drinks, and extensively in dyeing and calico printing; the acid is also used as a remedy for scurvy. (See F. Challenger on "The Production of Citric Acid by Fermentation Processes" (*Ind. Chem.*, 1929, v., 181); "Citric Acid Supplies" (*C.T.J.*, 1929, **85,** 391), and *Ibid.*, 1926, **79,** 331, 361, 395.)

Citrates of the alkalies are soluble in water.

Calcium Citrate, which can be prepared by adding an alkali citrate solution to one of calcium chloride, is a white powder insoluble in water. As manufactured from lime-juice by neutralization with whiting or chalk, an account is reproduced in the *C.T.J.*, 1929, **85,** 394.

Citrate of Iron and Ammonia (Iron-Ammon Citrate, B.P.)—A phar-

CITRIC ACID (*Continued*)—

maceutical preparation used as a tonic, being a reddish deliquescent compound soluble in water.

Citrate of Iron and Quinine—A pharmaceutical preparation used as a tonic.

CITRON (CEDRAT) OIL, from *Citrus medica* (peel), contains 5 to 6 per cent. citral, together with limonene and dipentene, has a sp. gr. of 0·851 at 15° C., opt. rot. +67° to +80° at 20° C., and ref. ind. 1·475 at 20° C. The fruit is used in perfumery and for making candied peel.

CITRONELLA OIL (Lana Batu)—A limpid, yellowish to yellowish-green essential oil distilled from the grass *Andropogon nardus,* which yields from ½ to 1 per cent. It contains geraniol, citronellal, and methyl eugenol; is soluble in alcohol, ether, etc.; has a sp. gr. of from 0·885 to 0·9 at 15° C., ref. ind. 1·4811 to 1·4830 at 20° C., and op. rot. 0° to 10°. It is used in the perfumery trade, for scenting soap, and as a pleasant antiseptic and insectifuge.

The Java and Burma oils are of much the same general character as the Ceylon oil, which is distilled from the fruit of *Tetranthera citrata,* and of which nearly 1½ million lbs. was exported in 1924, whereas the Lana Batu product is inferior and produced from a hybrid grass. Whereas, however, the Ceylon oil is said to contain from 55 to 64 per cent. geraniol, the Java oil content is from 80 to 92 per cent. (A. W. R. Joachim, *B.C.A.*, 1930, B, 394). The commercial utilization of the Java oil—for the production of citronellal, geraniol, and citronellol—is subject of a paper by O'Donoghue, Daum, and Ryan (*B.C.A.*, 1929, B, 452). (See also *Analyst*, 1931, **56**, 106.)

CITRONELLAL ($C_{10}H_{18}O$)—An aldehydic constituent of citronella, lemongrass, and some varieties of eucalyptus oils; sp. gr. 0·855 to 0·858, and b.p. 205° to 208° C. (See Waterman and Elsbach, *B.C.A.*, 1928, B, 654; 1929, B, 542; and A. Verley, *B.C.A.*, 1928, B, 1138.)

CITRONELLOL ($C_{10}H_{20}O$) is described as an unsaturated monohydric alcohol, sp. gr. 0·862, b.p. 177° (17 mm.), found in attar of roses, and said to be contained to extent of about 25 per cent. in Spanish geranium oil, also in the *Eucalyptus citriodora* oil; obtainable by reduction from citronellal, and used in perfumery.

CITRUS FRUITS INDUSTRY—The oils of the citrus or Aurantiaceæ group include lemon, bergamot, orange, neroli, mandarin, and lime oils, Italy being the largest producer, while the same fruit industry is an important one in California, Spain, France, and the West Indies. Fungal wastage of citrus fruits and grapes, oranges, and apples is effectively controlled by the maintenance of a definite strength of acetaldehyde vapour in the storage vessels, and any of the vapour absorbed by the fruit is destroyed by some mechanism within the fruit.

The waste product (pastaccio) of the citrus fruit industry—that is, the peel and membranes of the pressed fruit—is stated to constitute an excellent binding material for making briquettes when moistened and mixed with coal dust. (See W. V. Crueso on "Citrus By-Products in Sicily," *Chemical and Metallurgical Engineering*, February 23, 1925.)

CIVET—An unctuous secretion of revolting odour, from two glands near the anus of the civet cat of Abyssinia (*Viverra civetta*); soluble in hot alcohol and ether, used in perfumery and for scenting soap. When suitably diluted it emits a jasmin-like fragrance.

CLAYS—Clays are of secondary origin, being derived from the decomposition and disintegration of various primary rocks, so that they consequently vary in composition and size of their constituent particles.

Kaolins (terra-alba, China clay, white bole) or various descriptions of white clay are found in large quantities in Cornwall and Devonshire, Ontario, Australia, the U.S.A., British Columbia, the Cape, and elsewhere. Large deposits also occur in the province of Saskatchewan, ranging from the lower grades used for bricks and tiles, to a kaolin which burns quite white. Broadly they may be described as natural hydrated compounds of alumina and silica (silicate of aluminium) of density 2·5 to 2·7, which become plastic when sufficiently moistened, and in which the proportions of alumina, silica, and water vary greatly.

According to L. E. Jenks, the plasticity of clay results from the formation in its moistened condition of a continuous, gelatinous, external phase through the action of water on the material forming an enveloping surface around the non-gelatinous particles and aggregates contained in the clay. (See *B.C.A.*, 1930, B, 13; also Hind and Degg concerning the mechanical measurements of clay plasticity (*B.C.A.*, 1930, B, 989); E. J. C. Bowmaker respecting a modification of K. Pfefferkorn's method for this measuring (*Chem. and Ind.*, 1930, **49**, 1082); Gregory (with others) (*B.C.A.*, 1930, B, 580) and J. D. Davis (*Ind. Eng. Chem.* (*Anal.*), 1931, **3**, 43) dealing with the same subject-matter.)

The following analytical figures of two clays have been published: A being London clay, which is a most impracticable material, and B being a good Scottish fire-clay, so that such analyses do not furnish much information concerning their properties and respective values for various applications.

	Silica.	Alumina.	Iron Oxides.	Lime.	Alkalines.	Water.
A	51	28	1·5	0·5	1	19
B	52	28	1·5	0·5	1·5	20

Japanese acid clay is represented as of average formula $Al_2O_3,6SiO_2.nH_2O$, n being about 6 (K. Kobayashi, *B.C.A.*, 1932, B, 228).

Clays with high alumina content are better for nearly all applications than those of low content.

China clay, as mined in Cornwall and Devonshire on a large scale, conforms nearly to the composition $Al_2O_3,2SiO_2,2H_2O$, and is chiefly produced by the disintegration of *pegmatite*—a kind of granite—supposed by some to have been brought about originally in nature by the action of hydrofluoric acid supplemented by that of air and water. Washed down with water and after partial drying pressed into blocks,

CLAYS (*Continued*)—

it is chiefly used in making pottery and stoneware, the output in 1912 having reached nearly a million tons. According to a Parliamentary return, 801,500 tons of China clay and 63,612 tons of China stone were produced in Cornwall in 1927.

One method of separating clay from coarse and associated impurities consists in pulverizing it and transferring to a tunnel in which a current of air is used to carry away the finer particles, leaving the coarse ones behind. The tedious process of sedimentation attendant upon treatment by levigation can be hastened by electrical means, the clay being mixed with water and some alkali or other peptizing agent in the nature of an electrolyte, and then subjected to an electric current, by which means the particles of clay, aided by mechanical stirring, are uniformly distributed throughout the solution, and the impurities (mica, felspar, quartz, and iron compounds) are either precipitated or migrate to the cathode. The purified clay is deposited on the positive pole in a more or less dehydrated state, is much purer than the ordinary product, and, after drying, can be used in making porcelain of high quality.

When heated to 500° C., China clay is decomposed into free silica, alumina, and water, and upon continuing the heat up to from 1,200° to 1,300° C., the silica and alumina recombine. Other constitutional changes occurring in clays upon heating are referred to elsewhere. (See Sillimanite.) China clay is used largely as a "filler" in paper-making, pottery manufacture, the sizing of textile fabrics, glass-making, wall-paper printing, alum manufacture, and to some extent in compounding paints, linoleum, ultramarine, and many other materials.

Colloidal clay belongs to the class of suspensoids, and is reversible in the sense that the particles can be dispersed in water or thrown out of colloidal solution by suitable electrolytic means. Its quality is improved if minimum viscosity be maintained by the addition of alkali to the clay-casting slip. It is sometimes used for the treatment of dysentery, cholera, and ulcerative colitis; also for the preparation of certain pills and ointments, the clarification of liquids, and in the manufacture of copying-ink pencils, rubber, paints, cleansing powders, toilet articles, etc. It finds use in place of soap in wool-scouring, owing to its capacity of absorbing dirt and grease and removing unsaponifiable matters; but it has the disadvantages of being insoluble, and does not hydrolyse like real soaps. (See "Devulite" and "Stockalite.")

"Emol keleet" is a refined preparation of white clay used in making pharmaceutical preparations.

The following standards have been suggested for china clay: for coating, not more than 0·1 per cent. grit; for fine papers, not more than 0·5 per cent.; while low grades, containing from 5 to 10 per cent. mica, should be commercially described as mica clays (J. Strachan). The higher grades, used in the paper and textile trades, are designated "bleaching" clays, and the potting varieties, such as the "ball clays" of the Bovey basin and Poole district of Dorsetshire, are used for pottery and stoneware, but are distinct from the real kaolins or China clay.

CLAYS (*Continued*)—

A refractory of the nature of carbonized clay is recommended for use in making filter-beds and high-class acid-resisting ware, having, it is reported, a hardness just short of carborundum, while carbonized bricks conduct with twice the efficiency of standard fire-brick.

Fire-clay, as used to make fire-bricks, is a natural mixture of kaolin and sand found beneath certain coal-beds, and is almost infusible; it is moulded and then burned at a high temperature.

The ordinary common clay or heavy loam is employed in the making of bricks, tiles, and coarse pottery, and other selected clays are used in the manufacture of Portland and other cements. The presence of iron oxides causes clay to turn red when burned into so-called "ballast."

Several methods of obtaining alumina from clay (of which good grades contain from 30 to 40 per cent.) have been suggested, and it is reported that aluminium sulphate can be readily and economically produced by first of all removing practically all the iron and most of the potash by acid treatment. (See Aluminium Oxide, p. 38.)

There are certain kinds of clay which are valued in China as delicacies.

For clay drying, the "Rotamisor" oil fuel burner has proved a highly efficient and simple apparatus. The "Schaffer Poidometer" is an American contrivance for automatically measuring and weighing mixtures of clays and water in substitution for the pug-mill and its operator. The "Thermotyme" is an instrument used in connection with drying clays and ceramics, and embodies in one case two variable thermometers, one of which controls the dry bulb temperature, and the other the wet bulb temperature. See A. T. Green (*Chem. and Ind.*, 1927, **46,** 511); "Some Physico-Chemical Properties of Clays," by G. Wiegner (*J.S.C.I.*, 1931, **50,** 65 T and 103 T); H. B. Oakley (*J.S.C.I.*, 1931, **50,** 221 T); G. W. S. Blair on "Measurements of the Plasticity of Clays" (*B.C.A.* 1931, B, 490); C. E. Marshall on "Dispersion of Clays" (*J.S.C.I.*, 1931, **50,** 444 T and 457 T); Taylor and Woodman on "Flocculation of a Sodium Clay Soil, etc." (*J.S.C.I.*, 1931, **50,** 203 T); H. Berridge on "Colloidal Nature and Water Content of Clays" (*Engineering,* 1930, **130,** 5-7, 61-63); H. Berridge (*B.C.A.*, 1930, B, 820); *C.T.J.*, 1932, **90,** 81; A. Scott's vol. 31 of the special reports, Depart. of Scientific and Industrial Research on "Ball Clays" (H.M. Stationery Office); book by A. B. Searle (Ernest Benn); *The Clay-workers' Handbook,* by the same author (C. Griffin and Co.); *Ceramic Tests and Calculations,* by A. I. Andrews (Chapman and Hall); and *Ceramic Chemistry*, by H. H. Stephenson (Davis Bros., 265, Strand, London); also Bentonite, Cements, Ceramics, Kalsomine, Kaolin, Porcelain, Refractories, Schists, Shale, Sillimanite, and Silica.)

CLEANSING—See Washing.

CLEVES ACID—See Acid (Cleves).

CLEVITE—A mineral hydrated uranium oxide, of crystal system, No. 1, and sp. gr. 7·5, containing occluded helium.

CLOVES—The undeveloped flower buds of the clove-tree (*Eugenia caryophyllata,* N.O. Myrtacea), indigenous in the Molucca Islands, and culti-

CLOVES (*Continued*)—
vated in the Malay Peninsula, Zanzibar, Java, Ceylon, etc. The yield of essential oil of cloves is from 12 to 20 per cent. as obtained by distillation of the buds and flower stalks with water; b.p. 251° C.; sp. gr. 1·048 to 1·070 at 15° C., ref. ind. 1·528 to 1·540 at 25° C., and rotation 0·20° to 2·30°. It is a pale yellow, pungent-smelling liquid containing from 78 to 98 per cent. of eugenol ($C_{10}H_{12}O_2$ or $C_3H_5C_6H_3(OH)OCH_3$), and a small quantity of an inactive hydrocarbon named humulene resembling in some respects caryophyllene. (See A. C. Chapman, *J.C.S.*, 1929, p. 359.) It exhibits strong antiseptic qualities, is soluble in alcohol and ether, and used in perfumery, for flavouring, as a preservative of office pastes, and for the relief of toothache.

Eugenol also occurs (79 per cent.) with safrole (14 per cent.) in the oil obtained by steam distillation of Massoi bark (species of *cinnamomum*) widely distributed in New Guinea. It has a sp. gr. of 1·069 and b.p. 253·5° C.; is slightly soluble in alcohol and less soluble in ether and water. It was found during the Great War to be of service in preparing plastic and transparent varnishes, of which aceto-cellulose was the base, for covering wings of aeroplanes. Isoeugenol is made from eugenol on a large scale as a step in manufacturing vanillin. To effect this, the eugenol, or oil of cloves, is heated with strong caustic potash whereby any terpenes present are distilled off, and then the potassium salt of eugenol is dissolved in aniline and, after removal of the excess of potassium hydroxide, again heated to 185° C. The resulting potassium compound of isoeugenol is then mixed with nitrobenzene and caustic potash in certain proportions and the nitrobenzene and aniline subsequently distilled off by use of steam. The product is next acidified and the isoeugenol extracted with toluene, from which it is freed by distillation and subsequently purified by recrystallization from toluene and finally from water. Its m.p. is 82° C., and it is stated to exhibit about 50 times the flavouring strength of the natural vanilla bean. (See Vanilla.)

CLUPANODONIC ACID—See Fish Oils.

COAGULATION—The more or less solidification of a "sol" to a gelatinous mass; solution of egg-albumin is, for example, coagulated by heating or by precipitation with acetic acid. The formation of rain may be regarded as another type of coagulation. (See "Coagulation," by G. Wiegner, *J.S.C.I.*, 1931, **50**, 55 T; E. Frankenberger, *B.C.A.*, 1930, A, 1367; Albumins and Colloid Chemistry.)

COAL—its Nature, Distillation, Carbonization, etc.—
Coal is generally regarded as the residual product from the natural decomposition of forests and other vegetable matters during enormous periods of time, and is a very complex mixture of carbon compounds, containing generally some proportion of nitrogen.

Deposits of coal are found in all parts of the world, and China is particularly rich, her coalfields being regarded as practically inexhaustible. The total output in Great Britain in 1931 was about 243,000,000 tons.

COAL (*Continued*)—

Armstrong (H. E.) regards coal as a synthetic product resulting from condensation processes. Bone opines that it contains a six-carbon structure, the two points of view being more or less in accordance (see E. F. Armstrong, *Chem. and Ind.*, 1931, **50**, 40); and H. Briggs has expressed the view that coal in all its varieties has undergone, and is still undergoing, slow spontaneous change involving the discharge of methane and water (*Chem. and Ind.*, 1931, **50**, 127).

The main body is supposed to result from splitting up of the lignocellulose molecule by the action of bacteria, fungi, and moulds, the lignin of the vegetable matter being transformed by various influences into ulmic substances, and finally coal. (See Tideswell and Wheeler (*J.C.S.*, cxxvii., 110, 124); reference to the thermal decomposition of cellulose under hydrogenation conditions, by A. R. Bowen and others (*J.S.C.I.*, 1925, **44**, 507 T); H. Strache (*B.C.A.*, 1927, B, 178), R. Lieske (*B.C.A.*, 1930, B, 540), and W. Fuchs (*B.C.A.*, 1930, B, 540).)

Coal is an indefinite and variable mixture of some compounds insoluble in pyridine, with cellulosic compounds soluble in pyridine but insoluble in chloroform, and another constituent of resinoid character which can be extracted by certain solvents such as benzene, pyridine, and chloroform, while upon the relative proportions of these bodies the technical value and industrial applications depend. A resin isolated from bituminous coal of the empirical formula $C_{31}H_{30}O_3$ has been described.

In one classification, the constituents insoluble in pyridine are known as α-compounds, those soluble in that liquid but not soluble in chloroform as β-compounds, and those soluble in both these liquids as γ-compounds, the two former being supposed to be derived from the vegetable celluloses and proteins.

In another terminology these are classified as α- and β-ultrahumins, the γ-ultrahumins representing that portion of the coal substance which is soluble in both solvents, but is precipitated by ether.

Bone prefers benzene under pressure of 500 to 700 atmospheres as solvent, because pyridine under prolonged action causes depolymerization of the coal substance. He regards coal as largely benzenoid in character and has shown that about one-third of its carbon content is present in the form of the C_6—benzene complex, and he and Armstrong (H. E.) think that coal is an organically re-wrought "condensed" material or a sort of natural "Bakelite" and not a mere residue.

Bituminous and sub-bituminous coals, when extracted with benzene under pressure, yield from 4·5 to 7 per cent. nitrogenous "humic" bodies, which are mainly responsible for their caking propensities, less than 1 per cent. resin, and important amounts of neutral wax-like nitrogenous substances of low oxygen content. The non-coking characters of these coals are attributed to the comparatively small amounts of the humic and resinous constituents.

Aniline used as a solvent is stated to furnish a means of differenti-

COAL (*Continued*)—

ating between grades of coal, the "fat" varieties yielding a relatively higher percentage of soluble matter as compared with the "lean" kinds. The soluble part is richer in hydrogen, poorer in ash, and gives a better coke than the insoluble part.

The moisture in coal may vary from 0·5 per cent. (as with some anthracites) to as much as 12 to 14 per cent. in outcrop coals.

Analyses of certain coals by S. R. Illingworth are given in the first three columns of appended table, as some illustrations of their composition, which varies greatly:

	No. 2 Llantuit.	No. 3 Rhondda.	No. 2 Rhondda.	Fusain.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Volatile matters	37·06	31·50	21·16	—
Fixed carbon	57·53	66·93	71·20	—
Ash	5·41	1·57	7·74	6·33
On dry ash-free coal:				
C	82·87	86·70	87·96	78·36
H	5·80	5·00	4·35	3·41
O	7·76	6·21	4·32	9·97
N	1·49	1·45	1·42	1·10
S	2·08	0·64	1·95	0·83

The No. 2 Llantuit coal is used for gas-making, and yields a very porous coke; No. 3 Rhondda coal is carbonized to produce a metallurgical coke, which is dense; and the No. 2 Rhondda coal is a "hard-coking" coal, and also yields a dense coke.

The ultimate compositions of some British coals are given in the following table by T. J. Drakeley and F. W. Smith:

	Leicestershire Non-Coking.	Derbyshire Non-Coking.	Lancashire Cannel.		South Wales Anthracite.
Carbon (per cent.) ..	76·44	78·48	79·55	82·07	88·41
Hydrogen ,, ..	4·90	5·71	5·81	6·15	3·41
Nitrogen ,, ..	1·53	0·93	1·19	1·54	1·04
Sulphur ,, ..	0·83	0·79	0·96	1·48	1·27
Ash ,, ..	2·52	1·38	5·17	2·38	3·85
Oxygen ,, ..	13·78	12·71	7·32	6·38	2·02
	100·00	100·00	100·00	100·00	100·00
Radium per grm. of ash × 10^{12} ..	2·66	3·91	1·28	0·042	0·78
Radium per grm. of coal × 10^{12} ..	0·067	0·054	0·066	0·001	0·03

COAL (*Continued*)—

"Fusain" is a constituent of coal of which a published ultimate analysis is incorporated in table given above. It is said to be a constituent to some extent of all anthracite coals, non-caking, and reduces the coking property of the coal in which it occurs. "Durain" is a granular, hard, homogeneous constituent of coal of dull matt surface; "Vitrain" is a bright coal constituent devoid of preserved plant structure; whilst "Clarain is a variety possessing a definite, smooth, glossy surface when broken at right angles to the bedding plane.

These four banded constituents are found in certain proportions in various coal seams, but while they differ in appearance, they are of approximately similar composition and yield the same products upon being heated. They are to be regarded only as terms to indicate the dull and bright bands of coal and the intermediate materials, and not as indicative of chemical composition, which can only be investigated by study of their thermal decomposition, the action of solvents, and the attack by processes of oxidation, hydrogenation, etc.

R. V. Wheeler is of opinion that to express the composition and quality of a coal fully, the contents of hydrocarbons, resins, resistant plant-entities, and ulmin compounds should be respectively specified and the degree of coalification of the ulmins indicated.

Francis and Wheeler have shown that although "a rational analysis of any coal can be given in terms of the proportions of free hydrocarbons, resinous compounds, organized plant entities, and ulmin compounds that it contains," such an analysis is insufficient to specify completely its quality inasmuch as the ulmin compounds of which it is mainly composed are not identical in character in all coals. (See *J.C.S.*, 1928, p. 2967.)

With respect to the view that the coking propensities of coal are necessarily inherent in "Vitrain" and (or) "Clarain," Bone thinks this is untenable. See articles dealing with the same subject by R. Quarendon (*Chem. and Ind.*, 1926, **45**, 468 and 483); R. A. Mott (*Ibid.*, 1926, **45**, 737); and H. D. Greenwood (*J.S.C.I.*, 1924, **43**, 363-365 T).

The gross calorific value of coal is generally determined by combustion in a Berthelot-Mahler bomb, and the net value is calculated by deducting the amount of heat in respect of each unit weight of water in the products of combustion (*Chem. and Ind.*, 1928, **47**, 986). An article on Goutal's method of estimating the calorific value of coal forms the subject of a paper by Taylor and Patterson (*J.S.C.I.*, 1929, **48**, 105 T).

It has been calculated that the non-combustible mineral matter in mined coal amounts to not less than 25 million tons per annum. (See R. Lessing on the "Inorganic Constituents of Coal," *J.S.C.I.*, 1925, **44**, 277 T.) Mr. Lessing's investigations would also appear to show that the influence of ash constituents or added inorganic compounds is fundamental in respect of the course of the primary thermal decomposition of coal. (See *J.S.C.I.*, 1925, **44**, 345 T, and Burrows and Wevell, *J.S.C.I.*, 1931, **50**, 229 T.)

COAL (*Continued*)—

The plates of inorganic material found in coal seams are derivatives of calcium carbonate, some of the base being replaced by ferrous iron, magnesium, and manganese, and are known as "ankerites."

Among other publications dealing with the constitution and chemistry of coal, see R. Quarendon (*Chem. and Ind.*, 1925, **44,** 676); Legg and Wheeler (*J.C.S.*, cxxvii., 1412); C. A. Seyler (*C.T.J.*, 1926, **78,** 479); R. V. Wheeler (*C.T.J.*, 1926, **78,** 480, and *Chem. and Ind.*, 1931, **50,** 335); Francis and Wheeler (*C.T.J.*, 1926, **78,** 1410); Francis and Wheeler (*J.C.S.*, 1931, p. 586); R. V. Wheeler (*J.S.C.I.*, 1926, **45,** 307 T); Cockram and Wheeler (*J.C.S.*, 1927, p. 700, and F. Fischer's lecture as referred to in the *C.T.J.*, 1930, **86,** 104; Holroyd and Wheeler (*J.C.S.*, 1928, p. 2669, and 1929, p. 633); Cockram and Wheeler (*Ibid.*, 1931, p. 854); and C. A. Seyler (*Chem. and Ind.*, 1931, **50,** 393); W. A. Bone (*Chem. and Ind.*, 1931, **50,** 407); and A. Eccles (with others) (*J.S.C.I.*, 1932, **51,** 49 T).

It has been ascertained that coal undergoes oxidation by air, one experimental result, which has been published, showing a gain of 3·5 per cent. by weight in one month at 100° C. The alkaline permanganate oxidation of coals yields products of the nature of carboxylic acids of benzene.

The spontaneous firing of coal is now attributed to direct oxidation, and as independent of any contained pyrites; the smaller the coal particles the greater is the danger; it is promoted by moisture, and the greater the oxygen content of the coal, the greater is the liability, so that coal, and particularly pulverized coal, containing more than 10 per cent. oxygen, may be dangerous. It takes but a small proportion of coal dust also to make an explosive mixture, experiments at the United States Bureau of Mines having shown that 0·032 ounce of average Pittsburg coal dust suffices to cause an explosion in contact with flame. The tendency to explode is reported to be proportionate to the fineness of division of the dust, and occurs most frequently in fine coal below 1·25 inches, or nut size. When the temperature reaches 140° to 150° F., it is likely to occur within a week or so. Storage heaps should be kept as free as possible from excess of air, and external sources of heat should be avoided. Wetting is stated to be without value, but a covering of wet fine coal which keeps away the air is beneficial. Calcium carbonate in precipitated form is used for "stone-dusting" mines, the principal function being to absorb heat, and so prevent a dangerous temperature arising. The material must be so fine that at least 50 per cent. will pass through a sieve of 200 mesh to the inch. (See Francis and Wheeler (*B.C.A.*, 1926, B, 1000; *Ibid.*, 1927, B, 434); Golbert and Wheeler (*B.C.A.*, 1930, B, 171); Mason and Wheeler on "The Inflammation of Coal Dusts: the Effect of the Presence of Firedamp" (H.M. Stationery Office); and *B.C.A.*, 1931, B, 426; Dusts and Dust Explosions.)

There are many varieties of coal, and they are roughly divided into hard and soft coals, the softer ones being used for fires and gas-making, while the harder ones contain more carbon, give out more heat when

COAL (*Continued*)—

burning, and are consequently more useful for steam-raising. Bituminous coal contains from 50 to 80 per cent. of carbon, and anthracite, a hard coal which burns with little smoke or flame, contains from 85 to 95 per cent., but is devoid of bitumen, or nearly so.

In burning, coal may be said to give back the heat and light which were originally taken from the sun by the plant-life from which coal is produced, although as domestically used, the process is very wasteful and unscientific, notwithstanding the comfortable appeal it makes to human susceptibilities.

Average coal contains from 25 to 30 per cent. volatile matter and when burned or roasted, the products of its destructive decomposition thus effected, vary according to its character, the temperature employed, and the proportion of air that gains access to the burning mass. The decomposition points of different coals forms the subject of a research by R. Holroyd and R. V. Wheeler (*J.C.S.*, 1928, p. 3197). It begins to yield free carbon at about 500° C., although decomposition proceeds below this temperature, and it seems probable that the formation of free carbon results from the decomposition of the cellulose constituents of the coal.

The destructive carbonization of coal and allied products is always accompanied by the fusion of some of the resulting compounds, accompanied by the evolution of gas in the form of bubbles, from which the structure of coke is derived, while varying temperatures affect the character of the resulting coke. For instance, it is on record that a coal of sp. gr. 1·27, when carbonized at 550° C., gave a coke with a porosity of 44·7 per cent. and sp. gr. 1·59, the total volume being 3 per cent. greater than that of the original coal. At 850° C. the coke had a maximum porosity of 52·5 per cent., a sp. gr. of 1·87, and was much harder than the coke obtained at 550° C. At 1,100° C. a hard coke resulted, having properties resembling metallurgical coke, with a porosity of 45 per cent. and sp. gr. 1·87. (See M. Barash on "The Coking of Coal," *J.S.C.I.*, 1929, **48**, 174 T.)

When the direct object of coal distillation is to obtain coke for use in connection with the production of iron and steel, it is coked in specially constructed ovens at from 1,000° to 1,350° C., resulting in the production of hard coke containing less than $\frac{1}{2}$ per cent. of volatile matter, to the extent of from 60 to 70 per cent. calculated upon the coal used. The volatile parts of the coal constitute the coking loss; the tar and ammonia being recovered and the generated gas being burned in a way to assist heating of the ovens or otherwise utilized. (See Coke Ovens.) According to E. V. Evans and his colleagues, if coal be reduced to a fine powder, then compressed under a pressure of 10 tons to the square inch and carbonized, a coke of remarkably uniform structure is obtained, possessing the combustibility of charcoal and constituting a practically smokeless fuel.

The use of pulverized coal by forced air injection as a rival to mechanical stoking for both land and ship boilers has recently made great progress. The "Lopulco" installation is a favoured one, the

COAL (*Continued*)—

supply of coal and air being controlled by the flow of steam in the main. It gives higher efficiency, requires less air for combustion, thus securing a higher furnace temperature with high carbon dioxide content (16 to 18 per cent.), absence of carbon monoxide and smoke, while the ash is almost free from unburnt carbon. Certainly for marine purposes pulverized coal presents advantages in resembling oil in some respects, such as the control of combustion and elimination of stoking. Owing, however, to the differences in the varieties of coal, due regard must be paid to the manner in which the pulverized material is burned, as some kinds exhibit a tendency to cake, thus presenting difficulty in effecting rapid combustion. (See Elliott and Hollands (*C.T.J.*, 1924, **74**, 277).)

For drying and grinding, the "Rema" mill and vacuum system are stated to be valuable.

Of the 180 to 190 million tons of coal annually consumed in the United Kingdom, about one-fifth part is carbonized in gasworks or in coke-ovens (for the manufacture of metallurgical coke), and about 20 per cent. is used domestically. Most domestic grates radiate from 20 to 24 per cent. of the theoretical heat value of the coal, coke and anthracite yielding the higher radiation—viz., about 30 per cent.

As used for gas-making—so that it is not allowed to burn—the coal is heated in retorts to about 1,800° F. (982° C.), and yields, in addition to the gas, watery ammoniacal liquor and tar, which pass over in a vaporous condition and are condensed, leaving soft coke, containing only about 1 per cent. of volatile matter in the retorts. One ton of average coal as carbonized at gasworks yields about 12,000 cubic feet of medium quality (town) gas (550 B.Th.U. per cubic foot), 13½ cwts. of coke and breeze, 25 lbs. ammonium sulphate, 10 gallons coal tar, and 2½ gallons benzol.

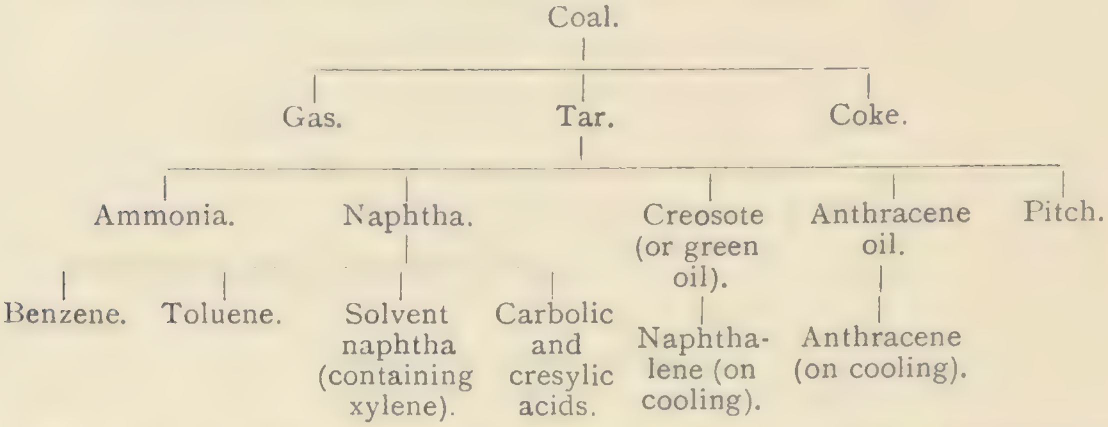
Crude gas liquor containing ammonia is used to some extent in dilute solution as a fertilizing agent. The coal tar, which has a sp. gr. of about 1·1 to 1·2, is afterwards distilled in large iron retorts heated by fire, and yields an average per ton of approximately 5 gallons ammoniacal liquor, 6 gallons crude naphtha, 26 gallons light oils, 17 gallons creosote oil, 38 gallons anthracene oils, and 12 cwts. pitch (left behind in the retorts), which is run out whilst hot and semi-fluid. It is from the primary distillates of coal tar that many explosives, drugs, dyes, and disinfectants are produced.

The temperatures at which the several distillates are obtained and the products which are eventually obtained from them may be roughly expressed as follows:

1. Ammonia liquor comes over up to about 150° C.
2. Light oil (containing carbolic and cresylic acids, solvent naphtha, benzene, and toluene) at from 150° to 220° C.
3. Creosote oil (containing naphthalene) at from 220° to 280° C.
4. Anthracene oil or "yellow oil" (parent of alizarin) at from 280° to 350° C.
5. Pitch left in the retorts ranging up to about 60 per cent. of the whole tar, and said to yield in all some 200 different organic compounds.

COAL (*Continued*)—

This may be shown diagrammatically as follows:



By the ordinary method of distillation, tar yields approximately 57 per cent. of oily products and 43 per cent. of pitch, but these proportions vary according to the temperature and pressure used, and it is possible by observing suitable conditions to obtain as much as 73 per cent. oils and only 27 per cent. pitch, the higher percentage of oils being due to some extent to the cracking which takes place when using the "Wilton dehydrating coils," by means of which these results are obtained.

As distinct from the ordinary process of tar distillation, a superheated steam method known as the *Ab-Der-Halden* system appears to present some advantages in certain circumstances. In this process the tar is raised to the maximum temperature required (300° C.), and grades down the condensation products in a way that finishes with the lightest volatiles in the order pitch, anthracene oils, heavy, middle, and light oils. Two rotating hearths are used, the coal being dried in the upper one by contact with combustion gases and the lower one is indirectly heated; dust is carried away with the gas and the tar has a free carbon content of 3·5 per cent. (See H. J. V. Winkler, *B.C.A.*, 1929, B, 422.)

Gasworks are reported to have an annual production of 1,000,000 tons of tar, and over 1,500,000 tons of tar are annually carbonized in British coke-ovens.

In round numbers, a ton of average coal produces, by direct combustion, 30,000,000 British thermal units, of which in the best steam-engine practice about 19 per cent. can be obtained as power.

Low-temperature carbonization of coal, brown coal, shale, tar sand, torbanite, peat, wood, and other materials has been the subject of much research work and many processes, but technical and other difficulties yet remain to be overcome to produce thoroughly satisfactory results.

The "Coalite" process employs the coal in a stationary state in narrow cast-iron retorts heated externally. There are works at Barugh and Askern and a smokeless fuel "Coalite" plant on the Parker system is installed at the works of the South Metropolitan Gas Co., capable, it is understood, of treating 2,000 tons coal per week. In a recently given account of this process it is alleged that the smokeless fuel so produced is quite satisfactory for household use, has practically the same composi-

COAL (*Continued*)—

tion and heat value of the better anthracite coals; further, that each ton of coal yields about 4,000 cubic feet of rich gas, 14 cwts. of "Coalite," 18 to 20 gallons of crude oil, and from 2½ to 3 gallons of good petrol, while the crude oil can be cracked and thus made to give a further supply of petrol together with fuel oil. (For further details of the "Coalite" process, see D. Brownlie, *Chem. and Ind.*, 1929, **48,** 1243.)

In the Sutcliffe-Speakman process the coal is powdered and mixed with about 20 to 25 per cent. powdered coke breeze, which mixture can be briquetted without the use of any other binding material, and it is stated that, irrespective of the temperature used, even when the volatile matter left in the residue is only about 2 per cent., it will burn quite readily in an open grate like coal without smoke, and is devoid of the practical objections appertaining to coke. A temperature of over 1,000° F. is recommended, and 1 ton of coal is stated to yield 10,000 cubic feet of gas of about 550 B.Th.U. per foot, 20 to 25 gallons oil, and about 35 to 40 pounds of ammonium sulphate, the whole of the nitrogen content of the coal being converted into ammonia.

In the "Maclaurin" process, external heating is not used, the distillation being effected in a vertical retort of great height by the hot gases formed in the lower part, steam and air being employed in the production of a hard smokeless coal named "Kincole." The process is said to be not only applicable to bituminous coal, but also to shale, and a description of it as now carried out is given by D. Brownlie (*Chem. and Ind.*, 1929, **48,** 619).

In the "Pure coal briquette process," an internally heated retort is used, and the coal subjected to a stream of superheated coal gas, the coal being first cleaned by froth filtration and after drying pulverized, and then briquetted under great pressure without a binding material. This method is said to yield a fuel good for domestic use and as metallurgical coke.

In the "McEwen-Runge" process, pulverized coal is passed down an internally heated tube of some 70 feet high, whereby carbonization is said to be effected in a few seconds, the volatile and gaseous products being collected at the top of the retort and the gas burned under the boilers after adequate treatment, attended with recovery of the by-products, while the low-temperature fuel is collected at the retort's base.

In the "Julius Pintsch" process the coal is carbonized in front of water-tube boilers at 1,000° to 1,250° F.

In the "Wissner" process the crushed coal is "thermodized" in a long externally heated rotary retort at 500° to 600° F. in a current of heated air. The so-named "Aicher" and Davidson processes also employ rotary ovens. (See *Ind. Chem.*, 1931, vii., 403.)

The "Staveley Markham" process is described as of special interest in connection with the utilization of small non-coking slacks.

The so-called "Plassman" process is described by D. Brownlie and many others in his paper on "Low-Temperature Carbonization" communicated to the Institution of Mining Engineers. (See *C.T.J.*, 1926, **78,** 268; and **79,** 343; and *B.C.A.*, 1930, B, 345. See also T. Burdekin,

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B.C.A., 1927, B, 288; a paper communicated to the Diesel Engine Users' Association on March 30, 1928; and accounts of the "Babcock" process, *Chem. and Ind.*, 1930, **49**, 92, and *Ind. Chem.*, 1931, vii., 149.)

The average yield per ton of the Northumberland coal used in the "Babcock" process is given by Mr. Brownlie as follows:

(1) Gas, 35,000 to 37,000 cb. ft.; 80 B.Th.U. per cb. ft.
(2) Crude light oil (*a*) scrubbed from gas, 2 galls.
(*b*) fractionated from tar, 2·7 galls.
(3) Low-temperature tar (dry), 14 galls.
(4) Low temperature fuel, 14 cwts. (70 per cent.)

and the process (in course of which the hot fuel produced is used for steam production) is described as a profitable one.

The "Piron-Caracristi" process for the low-temperature carbonization of powdered coal is based upon heating it in conveyers floating on and travelling over a molten lead bath at a temperature of 1,200° F., and keeping the whole of the lead in motion. A very rapid distillation is said to be effected with a great saving of time, and attended with but little "cracking." The liquid products are described as very fluid, containing little pitch and of excellent quality, the yield of petrol being greater than that of benzol by the higher temperature process, while the gas is of high quality (about 750 B.Th.U.), and as it is limited in extent (being formed to the extent of about 4,500 to 5,000 cubic feet to the ton) the condensing capacity is reduced accordingly. The semi-coke thus produced is reported as excellent for steam-raising, its density being 1·1.

The "K.S.G." process is conducted in very long rotary cylinders externally heated, using bituminous coal dust and "smalls" at about 925° to 1,025° F.; a ton of average coal giving from 3,500 to 5,000 cubic feet of rich gas of 800 B.Th.U. per foot, 3 gallons of light oil scrubbed from the gas, 15 to 20 gallons of low-temperature tar, and 14 cwts. of smokeless fuel. (See D. Brownlie, *Chem. and Ind.*, 1929, **48**, 569.) Some details concerning the conduct of the process as carried out at New Jersey (U.S.A.) will be found in the *Ind. Chem.*, 1929, v., 387.

An Italian process applicable to lignite depends upon the application of superheated steam, and is said to give 45 per cent. good coke free from sulphur and phosphorus, clean, hard, and of a calorific value of 6,500 B.Th.U., with excellent yields of ammonia and tar.

A low-temperature carbonization plant installed at Ashby-de-la-Zouch consists of an iron cylinder lined with fire-brick slightly inclined to the horizontal and rotating on its own axis, in which screened coal, after a preliminary drying, is passed through it whilst heated by the combustion of "producer gas" at the lower end. The hot gas is forced up through the charge, thereby releasing the primary oils, which are carried away and condensed, while the coke automatically falls out at the lower end by gravity. The temperature at the lower end of the cylinder (which is about 90 feet long) is about 550° C., and at the upper end about 200° C. Each ton of coal yields about 14 cwts. of semi-coke

COAL (*Continued*)—

and about 20 gallons of crude oils. At the time of making this note four more retorts were about to be erected, bringing the capacity of production up to about 750 tons a day.

The description of another low-temperature carbonization plant at Dunston is given in the *Ind. Chem.*, 1928, iv., 473; that of the Bussey Coal Distillation Company at Glenboig (*Ibid.*, 1929, v., 327), and Report on test by the Director of Fuel Research, Nov. 7-12, 1930 (H.M. Stationery Office). "The general principle of this (last-named) process is the progressive low-temperature carbonization of coal, cannel, torbanite, shale, lignite, and similar material in a vertical retort of great height," as described by D. Brownlie (*Chem. and Ind.*, 1929, **48**, 934).

While one object of low carbonization processes is to obtain coke for domestic use free from sulphur and smoke production, another important point to be borne in mind is the possibility of producing petrol and Diesel oils from the liquid products which are rich in aromatic phenols by vapour-phase cracking or hydrogenation. The tar oils are separated as far as can be done under existing circumstances by distillations and extractions with various solvents yielding phenols, from which resins of the bakelite type can be reduced, neutral oils (which can be used as liquid fuels and lubricants), waxes, and a number of nitrogenous bases.

The composition of the aqueous liquors obtained from the low-temperature carbonization of coal has been investigated by G. T. Morgan and others (see *J.S.C.I.*, 1929, **48**, 89 T, and *Ibid.*, 1931, **50**, 72 T).

The decomposition products of coal *in vacuo* have been so far little studied, and should furnish valuable information. Such a process might possibly present great advantages over low- or high-temperature carbonization in contact with air. A paper on the subject by Holroyd and Wheeler is referred to in *B.C.A.*, 1929, B, 116. "The Formation of Cenospheres as a Means of Studying the Swelling Capacity of Coal" is subject of a paper by Carlile and Sinnatt (*J.S.C.I.*, 1930, **49**, 355 T). Problems in the coal industries are dealt with by H. J. Rose (*Chem. and Ind.*, 1928, **47**, 1301), and by Spiers and Finlayson (*Ind. Chem.*, 1926, ii., 315); "The Future of High-Temperature Carbonization," by L. H. Sensicle (*J.S.C.I.*, 1927, **46**, 1 T); "The Production of Clean Coal," by H. Louis (*Chem. and Ind.*, 1927, **46**, 545); and by others (*J.S.C.I.*, 1927, **46**, 229 T—250 T, and 270 T); "Low-Temperature Carbonization" (*Chem. and Ind.*, 1928, **47**, 1027); the Fuel Research Board Reports for 1927-1930 (H.M. Stationery Office); articles by N. Simpkin (*C.T.J.*, 1925, **76**, 395); D. Brownlie (*B.C.A.*, 1926, B, 651; *Chem. and Ind.*, 1927, **46**, 663); E. O. Henrici (*Ibid.*, 721); "The Mechanism of Coal Carbonization," by E. Audibert (*B.C.A.*, 1929, B, 501); "Behaviour of Carbonized Fuels in an Open Fire Grate," by Bligh and Hodsman (*J.S.C.I.*, 1927, **46**, 92 T) and by Milner, Dyde, and Hodsman (*Ibid.*, 1931, **50**, 113 T); a large-scale laboratory apparatus for the low-temperature carbonization assay of coals, described by N. Simpson (with others) (*J.S.C.I.*, 1929, **48**, 183 T); E. H. Smythe on "Low-Temperature Coal Distillation, etc." (*Chem. and Ind.*, 1931,

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50, 588); and works by R. Wigginton on "Coal Carbonization" (Baillière, Tindall and Cox); Wellington and Cooper (Chas. Griffin and Co.), Lander and McKay (E. Benn, Ltd., London), and North and Garbe (Sir Isaac Pitman and Sons, London).

At a high temperature sodium formate yields nascent hydrogen, and when Rhenish brown coal mixed with twice its weight of sodium formate and the same quantity of water are heated together up to 400° C. in an autoclave, the coal being hydrogenated becomes to some extent soluble in ether, and this extract, when distilled, yields a viscid high-boiling oil which can also be obtained direct by distillation of the original product.

When pulverized coal is suspended in a hydrocarbon and treated with hydrogen under pressure of 230 atm. at 430° C. it is largely transformed into liquid hydrocarbons of imperfectly known composition (see Skinner and Graham, *B.C.A.*, 1927, B, 242; F. Bergius, *C.T.J.*, 1927, **80,** 3; Berginization, Brown Coal, and Hydrogenation). According to the Report of the Department of Scientific and Industrial Research Board, 1929-1930 (H.M. Stationery Office), it is possible to obtain 120 gallons of light spirit accompanied by some heavier oils—that is, about 40 per cent. of the coal—by a process of hydrogenation. Practical difficulties have been experienced by cracking of the iron retorts used and the undue access of air, but the Fuel Research Department has now succeeded in constructing an improved fire-clay retort of great promise, and it is reported that by a process of hydrogenation at Billingham, using a semi-commercial plant and clean, dry coal, 60 per cent. by weight has been obtained as refined petrol which has been successfully used in motor vehicles of all descriptions. Calculated on the dry, ash-free coal, the primary yield of liquid products is 75 to 80 per cent. (See Lord Rotherford's speech, House of Lords (*The Times,* May 21, 1931, and *The Times,* August 11, 1931); Sir H. McGowan's letter (*The Times,* May 21, 1931); F. G. Donnan's letters (*The Times,* July 31 and August 24, 1931); Colin Buist's letter (*The Times,* August 1, 1931); and Sir R. Redmayne's letter (*The Times*, August 10, 1931).) By way of summary it may be stated that, while some processes of low-temperature carbonization of coal may, under favourable local and economical conditions and particular circumstances affecting the quality of the coal used, be profitably conducted, no one process applicable to coal generally and capable of yielding a satisfactory sulphur-free, smokeless fuel with a sufficiency of petrol and Diesel oil upon a profitable basis has yet been established; further, that hydrogenation of coal or the products of its low-temperature carbonization promises the best results. (See Salerni Process.)

The following information respecting coke and gas tars is taken from a work on coal tars by G. Malatesta (E. and F. N. Spon, Ltd.):

Coke-furnace tar is distinguished from that of illuminating gas production by a lower amount of free carbon and the different amounts of the various contents. The free carbon of coke-furnace tar does not exceed, as a rule, 10 to 12 per cent., and frequently the content is

COAL (*Continued*)—

between 2 and 6 per cent. As the carbon varies, so do the other constituents of tar. The distillation of different coke tars has given the following results:

	1	2	3	4	5	6	7	8
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Water	2·0	2·69	2·3	Trace	6·60	3·20	3·40	3·70
Light oil	1·5	1·38	3·7	6·5	2·30	0·80	4·10	3·20
Middle oil ...	7·0	3·46	9·8	10·5	10·20	5·00	10·70	10·50
Heavy oil ...	14·0	9·93	12·0	7·6	8·00	8·40	8·60	7·40
Anthracene oil ...	14·0	24·76	4·3	44·3	26·70	22·70	19·00	16·80
Pitch	60·0	56·44	67·0	30·5	49·19	58·60	55·40	57·20
Loss	1·5	1·34	0·9	0·4	0·28	1·30	1·60	0·20
Specific gravity ...	1·16	1·145-1·191	1·17	1·1198	—	—	—	—

According to Schniewind, the variations in composition of gas tars and coke-furnace tars obtained from various foreign coals are given by the table below.

Among the products extracted from tars are tar acids, creosote, pyridine, and anthracene. Tar and ammonia are also recovered from blast furnaces in which coal and coke are used in the manufacture of iron and steel, but the products obtained from this tar vary from those obtained from gas tar. Among these is a quantity of so-called phenoloids, or homologues of cresol, of much greater antiseptic and germicidal power than carbolic and cresylic acids, and they are largely used in the preparation of disinfectants. (See Tar.)

Fractions.	Coke-furnace Tar.		Gas Tar.		
	Canadian Coal.	Westphalian Coal.	German Coal.	American Coal.	
				Good.	Bad.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Light oil	1·26	6·55	2·5	1·65	6·14
Middle oil	14·73	10·54	2·5	10·66	5·03
Heavy oil	7·07	7·62	25·0	8·18	7·50
Anthracene oil	21·38	30·55	10·0	14·05	11·71
Pitch	53·03	44·35	60·0	61·16	68·25
Water	1·52	Trace	—	1·81	—
Loss	1·01	0·39	—	2·41	1·37
Free carbon	8·10	—	25·00	—	48·4
Specific gravity	1·088	1·1198	1·155	—	1·255

A process for the utilization of colliery waste consists in grinding it to powder, mixing with three or four times its weight of water, and then agitating the mixture after addition of a small proportion of an oil or tar distillate. This produces a froth, in which the particles of coal adhere to the air bubbles, forming a scum of purified coal which can be skimmed off and dried, whilst the heavier associated impurities (shales and "brasses") settle. One pound of the added reagent is stated to

COAL (*Continued*)—

suffice for each ton of the coal mixture, and the coal thus obtained is stated to be excellent for coking and making briquettes.

By the so-called "Trent" process of separating mineral matter from coal (available also for utilizing poor quality coals and lignites, which would not otherwise be economically used) an oil reagent is employed, resulting in the production of an admixture of coal with heavy petroleum oil, which is said to yield a plastic fuel. A non-caking coke is produced upon distillation, and the total heating value of the gas from 1 ton of such "amalgam" (consisting of about 70 per cent. coal and 30 per cent. oil) proved, in one experiment, to be 6,109,000 B.Th.U., as against 2,460,288 units for the combined gases from coal and oil, besides which, the total quantity of gas was greatly increased, this increase occurring, of course, at the expense of the tar. The experiment in question was conducted at 600° C. in an electrically heated apparatus.

About 90 per cent. of the coal cleaned in Europe is effected by the use of "jigs" or in "Pheolaveur" washes, but pneumatic separators are likely to be widely adopted in the future.

R. Lessing's method of coal cleaning is one by which clean coal can be produced at a cost comparing favourably with washing processes, the product being low in ash and giving a reduced cost for the production of pig iron. This "gravity separation" method as carried out by the Clean Coal Co., Ltd., at the Yniscedwyn Colliery is described in the *Ind. Chem.*, 1929, v., 361. As much as possible of the dust is first of all removed, after which the "float and sink" application follows (see Sinnatt and Davies, *B.C.A.*, 1930, B, 646).

The use of a saturated solution of calcium chloride and more recent developments in coal cleaning is the subject of an article by R. Lessing (*Chem. and Ind.*, 1931, **50,** 84); the "Hoyois Washer" is described by A. Grounds (*B.C.A.*, 1930, B, 1051); information respecting coal cleaning, its treatment by various processes, and its utilization (Report of the World Power Conference in *Chem. and Ind.*, 1928, **47,** 984 to 998 and 1022 to 1032). See also Reports of the Fuel Research Board for 1928, 1929, and 1930 (H.M. Stationery Office); *The Cleaning of Coal,* by Chapman and Mott (Chapman and Hall, Ltd., London), and book by H. Louis (Methuen and Co., London).

The most economical way of using coal for the production of electricity so far available is reported to be by use of the steam turbine, but even in this process more than one-half of the coal value is lost as waste heat down the exhaust pipe of the turbine.

The coal produced in this country in 1929 is given as 256,718,000 tons, and the U.S.A. annual production as 500,000,000 tons; the coke produced at British gasworks as 12,085,691 tons (including breeze), and that at coke-ovens as 12,753,358 tons, while the total home consumption of coal was estimated by E. W. Smith as 180,000,000 tons in 1924. (See F. H. Walker on a method of sampling coal cargoes (*J.S.C.I.*, 1925, **44,** 283 T); R. Lessing (*Chem. and Ind.*, 1927, **46,** 459); "The Action of Chlorine on Coal," by Eccles and McCulloch (*J.S.C.I.*, 1930, **49,**

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377 T and 383 T); "Results in Glover-West Vertical Retorts" (West's Gas Improvement Co.); "Sampling and Analysis of Coal for Export" (*Chem. and Ind.*, 1931, **50**, 42); *The Economics of Coal Mining*, by R. W. Drow (E. Arnold and Co., London); *The Microscopical Examination of Coal*, by C. A. Seyler, of the Fuel Research Department (H.M. Stationery Office); also Berginization, Brown Coals, Coke, Coke-Ovens, Colloidal Fuel, Gas (Coal), Hydrogen (Hydrogenation), Lignite, Ores, Peat, and Tar.)

COALESCENCE—See Emulsions (p. 308).

"COALITE"—See Coal.

COAL GAS—See Gas.

COAL HYDROGENATION—See Berginization and Coal, p. 214.

COAL TAR—See Coal and Tar.

COBALT (Co) **and its Compounds**—Atomic weight, 58·95 and isotope 59; sp. gr., 8·8; m.p., 1,480° C. This metal occurs in nature in several combinations with arsenic and sulphur, including *smaltine* (*smaltite*), or *speiss cobalt* (cobalt arsenide, $CoAs_2$); *cobalt glance* (*cobaltite*) (cobalt sulpharsenide, CoAsS), a compound mineral sulphide and arsenide ($CoS_2 + CoAs$), of crystal system, No. 1, and sp. gr. 6·0; and *cobalt bloom* or *erythrite* (a hydrated arsenate of cobalt, $Co_3(AsO_4)_2 8H_2O$, of crystal system, No. 5, and sp. gr. 2·95. The chief sources are Canada and Queensland, Australia.

The Canadian production of the metal in 1927 has been stated at nearly 400 tons.

The metallurgical treatment of certain cobalt ores consists of a combination of dry and wet processes designed to separate associated nickel by precipitation of cobalt sesquioxide (Co_2O_3) with bleaching-powder solution, the other cobalt compounds being prepared from the purified product, and the metal obtained therefrom by reduction processes, as, for example, with carbon in the electric furnace, or by means of hydrogen, or by the "thermit process," using aluminium powder. The crude cobalt oxide prepared as described contains some nickel, and although most of it can be removed by treatment with hydrochloric acid, it always contains a small proportion. To obtain analytically pure cobalt oxide, J. T. Morgan and Main Smith have devised a process as follows: the ore is first of all freed from associated arsenic in part, and the calcined speiss (consisting largely of arsenides and oxides) is dissolved in hot concentrated hydrochloric acid; the iron and arsenic removed as ferric arsenate by hot milk of lime; the metals of the second group removed as sulphides by hydrogen sulphide, and the remaining iron as ferric hydroxide by milk of lime. From the final liquid the peroxides of cobalt and nickel are fractionally precipitated with bleach liquor, the cobalt being separated nearly quantitatively before nickel. From the cobalt oxide purpureo-cobalt chloride ($Co_2(NH_3)_{10}Cl_2.Cl_4$) can be readily obtained, and from this compound analytically pure cobalt oxide.

COBALT (*Continued*)—

The metallurgical practice with the Belgian copper-cobalt ore differs from that above described. It is smelted in a water-jacket furnace at from 1,250° to 1,300° C., using an air supply whereby the copper is reduced to "black copper," which contains only about 0·7 per cent. cobalt, the remaining quantity of that metal passing into the slag, which contains 6·5 per cent., together with 5 per cent. copper and 9 to 11 per cent. iron. This slag mixed with ore containing over 6 per cent. cobalt (which is not concentrated) and 4 to 5 per cent. coke, together with some lime flux, is then reduced in an electric furnace of 400 kw. capacity, thereby effecting complete reduction of the copper and cobalt and some 75 per cent. of the iron. The resulting alloy of about 30 per cent. cobalt, 30 per cent. copper, and 25 per cent. iron is subsequently heated to 900° C., by which treatment it becomes brittle, and after it has been broken into small pieces, it is treated with sulphuric acid, which dissolves the cobalt and iron, leaving the copper suspended in the solution, after which the iron is separated by oxidation with air and filtration as hydroxide. The cobalt sulphate which then remains in solution is converted into oxide, which is subsequently reduced to the metallic state by standard methods.

Cobalt-tungsten-chromium alloys constitute good abrasives and can be deposited on certain iron and steel surfaces to protect them from wear, and also used for repairing the worn surfaces; while cobalt-tungsten-carbide alloys are successfully employed in machinery metals at high speeds and increasing the life of cutting tools. The hardness of these alloys on the Brinell scale varies from 1,250 to 1,400 as compared with 1,000 for the hardest steel (*C.T.J.*, 1930, **87**, 34).

The metal is pinkish-white, very hard, ductile, tenacious, and strongly magnetic. It is used in making many alloys, particularly cobalt steels for permanent magnets, cobalt-chromium high-speed tools, and in the field of electro-plating. (See H. E. Kershaw on "Cobalt-Chrome Magnet Steels" (*Ind. Chem.*, 1929, v., 47); and Stellite.)

There are a number of oxides, including the three definite ones—CoO, Co_2O_3, and Co_3O_4—all of which can be used as pigments, the monoxide being soluble in acids forming the ordinary cobaltous salts, including the soluble pink-coloured chloride, nitrate, and sulphate. All cobalt compounds give a deep blue to glass or to a bead of borax when melted together. (See Boron (Borax).)

Smalt (**Silicate of Potash and Cobalt**) is a fine blue glass used for colouring enamels, otherwise as a pigment and in the ceramic industries. It is prepared by roasting smaltine with quartz sand and potash, the fused mass being subsequently ground to a fine degree beneath water. Its superiority over ultramarine as a pigment lies in the fact that it is a fast colour under practically all conditions, but for many purposes it has been superseded by manufactured ultramarine.

Cobaltous Chloride ($CoCl_2,6H_2O$), a salt soluble in water, finds use as a colouring material, and when gently heated to 120° C. loses its pink colour and becomes blue by the loss of its water of crystallization; hence its employment in preparing sympathetic inks, the faintly written

COBALT *(Continued)*—

pink words becoming visibly blue upon warming of the paper on which they are written.

Cobaltous Nitrate ($Co(NO_3)_2 6H_2O$) is a reddish-brown, crystalline salt, soluble in water, also used in preparing sympathetic inks.

Cobaltous Sulphate ($CoSO_4 7H_2O$) is a pink, crystalline salt, soluble in water, and used in ceramics, whilst combinations known as cobaltous oleate ($Co(C_{18}H_{33}O_2)_2$), linoleate ($Co(C_{18}H_{31}O_2)_2$), and resinate ($Co(C_{44}H_{62}O_4)_2$) are employed as varnish driers. The resinate is made by heating a mixture of a cobalt salt with rosin oil, and the oleate from cobaltous chloride and sodium oleate.

Cobaltous Acetate ($Co(C_2H_3O_2)_2 4H_2O$) is a reddish, crystalline salt of deliquescent nature, soluble in water; used in the preparation of sympathetic inks and as a drier in respect of linseed oil.

Cobaltic Arsenate ($Co_3(AsO_4)_2 8H_2O$) is a violet powder, insoluble in water, used, as is also the natural erythrite, for painting on glass and porcelain.

Cobaltous Carbonate ($CoCO_3$)—A rose-coloured insoluble powder used as a pigment.

Cobaltous Phosphate ($Co_3(PO_4)_2 2H_2O$)—An insoluble pink powder used as a pigment and for painting porcelain.

Cobaltous Tungstate ($CoWO_4$)—An orange-coloured insoluble powder used as a pigment.

Cobalt-carbonyl—At 50-100 atm. pressure and at about 250° C. cobalt unites with carbon monoxide, forming shellac-coloured crystals of the chemical proportions $Co(CO)_4$, but of double this molecular weight, and if this be heated to 60° C. it quickly loses one-fourth of its CO, forming the tri-carbonyl $Co(CO)_3$.

Cobaltammines (**Ammonium-Cobalt Compounds**)—A great number of both cobaltous and cobaltic compounds of this class are known, the larger number containing the double atom $(Co)_2$. Tetrammonio-cobaltic chloride has the composition $Co_2Cl_6(NH_3)_4$, hexammonio-cobaltic chloride $Co_2Cl_6(NH_3)_6$, and so forth.

Purpureo-cobalt chloride is chloro-pentamine-cobaltic chloride. Many of the cobalt salts, including the hydroxide, resinate, borate, are used as driers in the manufacture of paints and varnishes.

The quantity of cobalt compounds used in the pottery and enamel trades is relatively small, as the amount required for blue colouring, decorative designs, and neutralising the yellow tinge in earthenware is generally about only $\frac{1}{5000}$ part.

"Cobalt with a Co-valency of Four and a New Series of Complex Compounds" is the subject of a paper by Percival and Wardlaw (*J.C.S.*, 1929, p. 1505). For a detailed account of cobalt, its compounds, their production and uses, see T. H. Gant (*Chem. and Ind.*, 1925, **44,** 157 and 191).

COBALT BLUE (Thénard's Blue)—Cobalt aluminate obtained by heating together cobalt sulphate and alum, phosphoric acid and zinc oxide being sometimes incorporated to vary the tints. With respect to its constitution, see Natta and Passerini (*B.C.A.*, 1930, A, 20).

COBALTINE (Cobaltite)—See Cobalt.

COCA—The dried leaves of plants of the genus *Erythroxylaceæ,* including *Erythroxylon coca,* which grows abundantly on the eastern slopes of the Andes and is cultivated in Bolivia, Peru, Brazil, Java, and Ceylon; containing cocaine and other alkaloids. (See also Waxes (Coca).)

COCAINE ($C_{17}H_{21}NO_4$)—A colourless, crystalline alkaloid of m.p. 98° C., constituting the active constituent of the coca leaf (*Erythroxylon coca*). The alkaloid is allied to atropine and can also be prepared synthetically. It is soluble in alcohol and ether, possesses great staying powers, and is used for deadening pain (local anæsthesia); a hydrochloride (soluble in water and alcohol) is used in ophthalmic operations. (See Coca, Novocaine, and "Borocaine.")

COCCULUS INDICUS—The fruit of a climbing shrub (*Anamirta paniculata*) and other allied varieties which grow on the coasts of Malabar and in Ceylon, etc. It contains about $\frac{1}{50}$ of its weight of a bitter principle named picrotoxin ($C_{30}H_{34}O_{13}$), which is a strong narcotic poison. It is occasionally employed in the form of an ointment for destroying *pediculi,* and the roasted berries are sometimes used for poisoning fish. Associated with picrotoxin is another substance—anamirtin ($C_{19}H_{24}O_{10}$), or cocculin ($C_{19}H_{26}O_{12}$)—which can be obtained in white, crystalline needles.

COCHINEAL—A reddish or purple colouring matter, containing carminic acid ($C_{22}H_{22}O_{13}$), obtained from the dried fecundated insects of *Coccus cacti,* which live on various plants (*Opuntia*) indigenous in Mexico, but which are also cultivated in many hot countries, including Guatemala, the West Indies, Teneriffe, Madeira, Algeria, and Java. The female insects only are collected, and after killing by drying or heating they are digested in hot water.

The colouring matter is prepared by treating the watery extract of cochineal with cream of tartar, alum, or acid potassium oxalate, which coagulates the albuminous constituents, and the colouring principle is carried down with the precipitate. It is soluble in water, alcohol, and ether, and contains about 50 per cent. of carminic acid, which gives well-defined salts. (See also Kermes.)

In the dry state, cochineal is an inodorous, dark red, granular material, which grinds to a fine deep red colour. Boiled with water it yields a dark red liquid, which can be changed to other colours by addition of various chemicals. It is used as a colouring for foods and medicines, also in the preparation of carmine and carmine "lakes," and for dyeing wool and silk scarlet.

The species known as the wild cochineal (*Dactylopius tomantosus*) is used for retarding the growth of the prickly pear in areas affected by

COCHINEAL (*Continued*)—
that plant which it destroys by sucking away the juice. (See Waxes (Coccerin).)

COCKLE-BURR OIL—A seed drying-oil, obtained by cold pressure (about 30 per cent.) from the kernels of *Xanthium echinatum*. It is a light, sparkling oil of pleasant odour and nutty flavour, with a sp. gr. of 0·9251 at 15·5° C., i.v. (Hanus) 140·8, and sap. v. 190·2.

COCOA—This name is often used indiscriminately, and it should be clearly understood that cacao yielded by *Theobroma cacao* (from which chocolate is made) is perfectly distinct from the cocoa-nut products of the species of palm named *Cocus nucifera*, as also from the palm oils derived from the *Elæis guineenis* and other species, including *Cocos butyracea*. (See Cacao, Cocoa-Nut, and Palm Oil.)

COCOA-BUTTER—See Cacao.

COCOA-NUT (COCONUT) OIL—A natural, semi-solid, white, edible fat (sp. gr. 0·925), extracted by pressure from the kernels of cocoa-nuts (*Cocos nucifera*) to extent of from 30 to more than 40 per cent., and much used in making soap, candles, confectionery, margarine, and for cooking. The fully matured nuts fall when ripe and produce on average about ½ lb. of copra. The oil is somewhat similar in composition to palm-nut oil, and is, to some extent, obtained from the same trees. According to E. F. Armstrong and others, the fatty acids of the kernel oil (contained as glycerides) include octoic (2 per cent.), decoic (2 per cent.), lauric (28 per cent.), myristic (22 per cent.), palmitic (12 per cent.), oleic (23 per cent.), linoleic (10 per cent.), and questionably 1 per cent. stearic acid; while those from the parings consist of octoic (9 per cent.), decoic (4·5 per cent.), lauric (51 per cent.), myristic (18·5 per cent.), palmitic (7·5 per cent.), oleic (5 per cent.), linoleic (1 per cent.), and stearic acid (? 3 per cent.).

Cocoa-nut oil is soluble in alcohol, ether, and carbon disulphide, has a sp. gr. of about 0·92, ref. ind. of 1·4488 at 40° C., sap. v. 233 to 253, i.v. about 7 to 10, Reichert-Meissl value 7·15 to 7·54, m.p. 26° to 28° C., and solidifying point of about 21° to 22° C. It has been shown that the oil from the testa of the cocoa-nut differs from that of the kernel in iodine and saponification values, that from the parings having higher values. Supplies come from the Malabar coast, India, Ceylon, South Sea Islands, Kenya Colony, Tanganyika, Uganda, N. Rhodesia, Nyasaland, British Guiana, Malay Peninsula, Jamaica, etc., and there are commercial grades known as "Cochin," "Ceylon," and "Copra Oil." The residual cake contains from 5 to 10 per cent. oil, and is used as a cattle food, whilst the fibrous portion of the nut provides the coir used for matting, cordage, etc. (See J. P. C. Chandrasena on "Chemistry of the Products of *Cocos Nucifera*" (Biochem. J., 1930, **24,** 1493); Collin and Hilditch on the "Component Glycerides of the Oil" (*J.S.C.I.*, 1928, **47,** 261 T); and A. E. Williams on "Coconut Oil in Confectionery" (*C.T.J.*, 1931, **88,** 632); and Copra.)

CODEINE (Methyl-Morphine) ($C_{18}H_{21}NO_3,H_2O$)—A colourless, crystalline, poisonous, organic base, of m.p. 152° to 155° C., soluble in water and alcohol, obtained from opium, and allied chemically to morphine; contained in the mother-liquor from which the morphine has been previously crystallized out; used in medicine. (See Opium.)

COD-LIVER OIL—See Fish Oils.

COFFEE—The beans are the seed of *Caffea Arabica, Caffea Literica,* the *Robusta* bean (*rubiaceous* order), and other varieties, indigenous in Southern Abyssinia, and cultivated largely in West Indies, Brazil, India, Java, Ceylon, etc. They are separated from the soft covering pods before they are exported, and contain a certain quantity of an essential oil, while caffeine (theine) ($C_8H_{10}N_4O_2$) is the active principle, present to the extent of about 1·87 per cent. on average. The solid fatty acid constituents of coffee-berry oil have been determined by Meyer and Eckert as 29 per cent. palmitic, 3 per cent. daturic, 14 per cent. carnaubic, 2 per cent. oleic, and 50 per cent. linolenic acids (*B.C.A.,* 1929, B, 254). The beans lose about half their weight by washing, and about 10 per cent. of the roasted product passes into solution by the process of making drinking coffee which acts as a stimulant. In conjunction with strychnine, coffee extract is used in hypodermic injections for treatment of poisoning by carbon monoxide. It is the roasting that develops the fragrant odour associated with coffee, of which there are many varieties, one of the best being the Mocha coffee from Yemen, in Arabia. Of roasted natural coffees from various localities, those from Novo Redondo and Mozambique contain the greatest and least amounts of caffeine—viz., 2·43 and 0·72 per cent. respectively (Pritzker and Jungkunz, *Analyst,* 1926, **51,** 355). Substitutes used as adulterants for coffee include chicory, caramel, roasted cereals, dandelion-root, and figs. Coffee parchment (endocarp) is sometimes used as an adulterant of bran and sharps. (See A. Valenzuela (*Analyst,* 1930, **55,** 139); and Caffeine.)

COGNAC OIL—See Œnanthic Ether.

COHESION—The power or force (molecular attraction) by which particles of homogeneous substances are held together. (See Capillary Attraction; also *Cohesion and Related Problems* (published by the Faraday Society, 1927).)

COHUNE OIL—Extracted from the kernels of the cohune palm (*Attelea cohune*), which yields on average 68 per cent., and grows in British Honduras, Guatemala, and Mexico. It is a yellowish, semi-liquid fat, of m.p. 18° to 20° C., sp. gr. 0·868, sap. v. 252, and i.v. 11 to 13·7. It is soluble in ether and benzol, is used in candle and soap making, also for cooking purposes; resembles cocoa-nut oil, and can be used in place of it for many purposes.

COINAGE—See Copper, Gold, Nickel, and Silver.

COIR—The outer coating or fibres of the cocoa-nut, used for making matting, brushes, small cables and rigging, and as a spinning material.

COKE—Properly prepared coke is an ideal solid fuel for house use, and burns completely in one stage with brilliancy and power. The "shatter

COKE (*Continued*)—

test" for coke consists in dropping 50 lbs. weight of it on to an iron plate, the "shatter index" being the percentage of the broken material remaining upon a 2-in. sieve. This index and the combustibility of coke are stated to be intimately related to the sp. gr., porosity, and water-absorbing capacity of the material (H. V. A. Briscoe). The standard method for the shatter test as adopted by the Midland, Northern and Scottish Coke Research Committee is described in *Chem. and Ind.*, 1930, **49,** 320.

The reactivity of coke based upon the reaction of $CO_2 + C = 2CO$, the recorded value being the volume of the carbon monoxide obtained from ·100 m.l. of CO_2 under standardized conditions, is the subject of technical papers by Jones, King and Sinnatt (obtainable at Adastral House, Kingsway, London). (See also T. J. Drakeley (*J.S.C.I.*, 1931, **50,** 319 T); Drakeley and Wilkins (*Ibid.*, **50,** 331 T); Key and Cobb (*J.S.C.I.*, 1930, **49,** 439 T); Muller and Jandl (*B.C.A.*, 1931, B, 660); description of a modern coke and by-products works (*Ind. Chem.*, 1930, vi., 101). With respect to the coking of coals, see several papers read at the Safety in Mines Station, Buxton, in July, 1929 (*J.S.C.I.*, 1929, **48,** 167-194 T, and 265 T).)

See also J. Weyman (*J.S.C.I.*, 1925, **44,** 50 T); A. R. Mott (*Ibid.*, 1927, **46,** 85 T); M. W. Travers (*Ibid.*, 1927, **46,** 128 T); M. Barash on "Coking in Coals" (*Ibid.*, 1926, **45,** 152 T and 176 T); R. Quarendon on "Cause of Coking in Coals" (*Chem. and Ind.*, 1926, **45,** 468 and 483); Hollings and Siderfin on "Coke in Relation to its Industrial and Domestic Uses" (*J.S.C.I.*, 1927, **46,** 76 T); F. S. Sinnatt on "Cenospheres and the Structure of Coke" (*J.S.C.I.*, 1930, **49,** 335 T); Oshima and Fukuda on "The Structure of Coke" *B.C.A.*, 1930, B, 226); Dent and Cobb (*B.C.A.*, 1929, B, 629); D. J. W. Kreulen (*B.C.A.*, 1929, B, 741); J. Roberts (*Ind. Chem.*, 1928, iv., 380); *Analyst*, 1929, **54,** 471; Technical Paper No. 25 (H.M. Stationery Office); *Coke and its Uses*, by E. W. L. Nicol (E. Benn, Ltd., London); *The Year Book* (1931), *Coke-Oven Managers' Association* (Benn Bros., Ltd.); *Coke for Blast Furnaces*, by Mott and Wheeler (London: the Colliery Guardian Co., 1930); Coal and Coke-Ovens.

COKE-OVENS—Nearly as much coal is carbonized in coke-ovens for the production of metallurgical coke as that consumed in gas making. The working of a battery of "Semet-Solway" regeneration ovens in a modernised plant is briefly described (*C.T.J.*, 1927, **80,** 37), and an account of "The New Becker Coke-oven Plant at Sheffield" (*Chem. and Ind.*, 1929, **48,** 400). The "Feld" process for the separation of the several constituents of coal tar from coke-oven gas is one of cooling in stages, as effected by a series of washers, the first three of which are cooled by the circulated condensate. The separation of ammonia and sulphur is carried out at 80°; the fourth washer is water-cooled, and condenses middle oil and water vapour, while benzol is removed by the fifth and final washer.

Some 11,093,094 tons of metallurgical coke are produced annually in the United Kingdom from coke-ovens of various types, specially

COKE-OVENS (*Continued*)—

selected coal being used for this high-temperature process, yielding tar (about 3 per cent. of the coal carbonized), 1 per cent. ammonium sulphate, and crude benzol (2 gallons per ton of coal carbonized)—that is, 630,000 tons tar, 210,000 tons ammonium sulphate, and 42,000,000 gallons of crude benzol.

Coke-oven gas is rich in hydrogen content (about 50 per cent.), and this may prove to be a valuable source for the supply of that gas in the future. The Bronn-Linde-Concordia process is one already in use for the production of pure nitrogen and hydrogen from that source. See E. W. Smith on "Coke-Oven Gas for Town Supply" (*Chem. and Ind.*, 1927, **46**, 98); description of a modern coke-oven plant (*Chem. and Ind.*, 1930, **49**, 454); review of the Kopper's "C.A.S." process as applied to British conditions, by E. W. Smith (*B.C.A.*, 1930, B, 89); C. P. Finn (*J.S.C.I.*, 1925, **44**, 354 T); and R. A. Mott and R. Wigginton on "Heating of Coke-Ovens" (*J.S.C.I.*, 1925, **44**, 350 T); *Coke-Oven and By-Product Works Chemistry*, by T. B. Smith (C. Griffin and Co., Ltd., London); Coal and Nitrogen (p. 614).

COLA NUTS—See Kola Nuts.

COLCHICINE ($C_{22}H_{25}NO_6$)—A yellow, crystalline, alkaloidal body, of m.p. 142·5° C., extracted from the seeds of meadow saffron (*Colchicum autumnale* [Linn.]); soluble in 22 parts of water, also in alcohol, chloroform, and ether. It is of poisonous character and bitter taste, and used in medicine. The alkaloidal content of the seeds is from 0·2 to 0·8 per cent.

COLCHICUM AUTUMNALE (**or Autumnal Crocus**) is a genus of Liliaceæ, which grows wild in many parts of England and throughout Europe, the root, bulb, and seeds being used in pharmacy for the preparation of remedies against gout and rheumatism. Colchicum is a medicine which acts very powerfully upon the liver and bowels, and must be used with care. It contains,, amongst other ingredients, from 6·5 to 8·4 per cent. of an oil of sp. gr. 0·9176, sap. v. 184·3, and i.v. 128·5. (See Colchicine.)

COLCOTHAR—A crude red oxide of iron obtained by roasting green copperas (ferrous sulphate). (See Iron (Ferric Oxide).)

COLD STORAGE—See Refrigeration.

COLEMANITE (**Borate Spar**)—See Boron.

COLEY'S ZINC PROCESS—See Zinc.

COLLAGEN—See Tanning.

COLLARGOL (**Colloidal Silver**)—A finely divided silver in soluble form, sometimes used as an antiseptic.

COLLIMETER—A telescope arranged to transmit a parallel beam of light. (See Light (Spectroscope).)

COLLODION—A solution of cellulose tetranitrate, or nitrated cellulose in ether and alcohol, largely used in photography, also as a coating for various materials (as in the making of balloons), in making patent leather, and in medicine. For general use, as a protective film for cuts,

COLLODION (*Continued*)—

it may be prepared by dissolving 40 grains of gun-cotton in a mixture of 3 ozs. of ether and 1 oz. of rectified spirit; the solvent, being very volatile, leaves the dissolved substance as a covering over the surfaces to be protected.

COLLODION COTTON—A product of the nitration of cellulose prepared in much the same way as nitrocellulose, containing about 12 per cent. nitrogen, and used in the manufacture of silk substitutes and lacquers. Its constitution and manufacture are described in an article by A. H. Bresser (*Ind. Chem.*, 1930, vi., 249).

COLLOID CHEMISTRY—The term *colloids* is ordinarily used to distinguish jellylike substances from definitely crystalline ones, and includes the living parts of animals and plants, such as albumin, casein, cellulose, and starch. While, however, the physical states of crystalloids and colloids appear widely different, it is alleged that by the application of X rays, proof of crystallinity in colloids has been afforded in respect of silica gels, the colloidal particle of gold, and certain vegetable fibres (cellulose and ramie fibre). In any case, many substances can be prepared both in crystalline and colloid ("gel") form, the difference being one rather of degree than essential.

According to Selmi and Nägeli, colloidal matter such as starch grains consists of larger units than molecules styled *micelles*, of crystalline character and of two sorts, one highly charged liked an ion and the other neutral, the latter being the bricks from which the larger structures are built up. (See Cellulose.)

The colloidal form, then, is a state or phase of matter, the term "phase" being used to indicate a homogeneous material or chemical system in liquid, solid, or gaseous form, a solid substance having as many phases as there are contained chemical individuals. The greater the complexity of a substance, the greater is the probability of its being in colloid form. One of the most complex colloid bodies is the human brain considered as a whole, and while it does not consist of one homogeneous compound, the number involved is relatively small, although by acts of hydrolysis it is easily broken down into a much larger number of still very complex bodies. It has been compared to a septum, on the one side of which is arterial blood and cerebro-spinal fluid of the ventricles, while on the other side is cerebro-spinal fluid of the arachnoidal space and venous blood.

Colloid chemistry has been defined by W. C. McC. Lewis as "the science which deals with the phenomena occurring at the interfaces which separate two contiguous phases, such interfaces being very large in extent relatively to the actual masses of the phases themselves."

A heterogeneous system is described as constituted of different portions, each being of homogeneous character marked off in space by separating boundary surfaces, and each such portion constitutes a phase.

The *phase rule* ($P+F=C+2$) is a mathematical expression of the equilibrium or relationship between the number of phases and components in a system and the degrees of freedom possible under given

COLLOID CHEMISTRY (*Continued*)—

conditions. The components are those constituents which can undergo independent variation in the several phases. Water, for example, exhibits two phases—viz., liquid and vapour—under ordinary condition of temperature and pressure, and corresponding to each temperature there is a definite vapour pressure, and only at certain points can the two remain unchanged. It can be made to assume another phase, that of ice, and at certain temperatures and pressures ice and water vapour may be in equilibrium.

Sulphur exhibits four phases—viz., liquid, vapour, rhombic crystals, and monoclinic crystals, the two latter being in equilibrium at the transition temperature. Taking C to represent the number of components, P the phases, and F the degrees of freedom, then $C + 2 - P = F$.

A solution of sodium sulphate has two components—viz., the salt and the water—and as at a temperature of 33° C. the solubility curves of the anhydrous salt and sodium decahydrate ($Na_2SO_4 10HO_2$) intersect, there are then presented four phases—viz., the anhydrous salt, the decahydrate salt, saturated solution, and water vapour. As the number of phases then exceed that of the components, the system is non-variant, since $F = C - P + 2$.

The equilibrium will change if any of the variables (temperature, concentration, and vapour pressure) be altered, and then one or more phases will disappear. Should one phase disappear, the system will become mono-variant (or have one degree of freedom), and if both of the solid phases disappear, two only will be left and it will become divariant, etc.

Some there are who think that all liquids of colloidal matter possess a definite structural orientation.

Colloid chemistry presents infinitely greater problems for solution compared with other branches (particularly those dealing with definitely crystalline substances), and is of great importance in physiological chemistry, as also in many industries in which colloidal bodies are dealt with, such as tanning, wood-pulp and paper-making, dyeing of textiles, the soap, paint, and varnish trades, etc.

Among inorganic substances, silicic acid and cuprous oxide may be obtained in colloidal form, also a number of metals by reduction of their salts. Sulphur affords another striking instance, being obtainable in a bright yellow labile state from its first melting-point up to 160° C., again becoming viscid on raising the temperature, whilst upon cooling to 100° C. it takes a distinctly new phase, solidifying in insoluble form.

Styrene (C_8H_8) is a hydrocarbon which polymerizes spontaneously upon standing into a jelly-like mass, and there are a number of so-named metallic organosols and metallic colloids known in various dispersion media.

Graham, who first of all studied colloid chemistry in any fulness, was aware that different dispersion media could be employed to displace each other without destroying the colloidal state, replacing, for example, the water of silicic acid "gel" with alcohol, sulphuric acid, etc.

A colloidal solution is really a two-phase system consisting of a fluid

COLLOID CHEMISTRY (*Continued*)—

medium and suspended particles, the suspended particles being present in relatively small quantity. These are called "dispersed systems," the substance present in excess constituting the dispersion medium and the other the dispersed phase. The main groups of such systems are repectively (1) mechanical suspensions, (2) colloidal solutions, (3) molecular solutions; the characteristic feature of every such system being the degree of dispersion or, in other words, the division of the dispersed phase, although no hard-and-fast line can be drawn between the three degrees.

Such systems, it will be seen, provide a very large surface of contact between the colloid body and its medium. The colloid state is merely a question of the size of the particles of the disperse phase, for when the latter are of molecular size an ordinary solution results, but when of larger particles the mixture is termed a dispersion, the colloidal realm lying between these two states.

Suspensoid and emulsoid sols consist of solid and liquid disperse phases respectively, in liquid continuous phases.

When a substance is introduced into such a system it is frequently found concentrated at the surface of one of the phases, thus presenting the phenomenon known as *adsorption*. Many dyes give colloidal solutions, the dyeing depending upon the adsorption of them by the fibres, and the same state of things is realized in the behaviour of hides to tannin solutions.

The tints of coloured glasses are frequently due to the metals being in a colloidal state, as, for example, in "gold ruby glass."

Most substances in colloidal solution—disperse particles—assume an electric charge towards their dispersion medium, and when suspended in water can often be coagulated or precipitated by physical agencies or by the addition of certain chemicals, as exemplified by the use of calcium hydroxide and aluminium sulphate to effect the precipitation of organic matters contained in sewage sludge.

It is well known that pollen grains suspended in water are in constant motion, and this so-called "Brownian" movement and other similar oscillatory movements observable in many colloidal mixtures are due to sources of energy within the fluids of a kinetic character—that is, collisions between the molecules of the dispersion media.

Among the terms commonly used in association with colloidal chemistry are those of *gel, sol, hydrosol, aerosol, suspensoids, emulsoids, sorption, adsorption, peptization, lyophile systems* and *cataphoresis*.

"Gel" is the name given to any gelatinous mass produced by slow change, physical action, or by addition of saline substances to the solution of a colloid body. A silica gel, for example, can be prepared by the addition of an acid (such as hydrochloric acid) to a solution of sodium silicate in such proportions as to set free all the silica, when upon standing the "gel" forms. This, when washed, dried, and finely pulverized, can be used as a substitute for charcoal for adsorptive purposes. It is also reported that colloidal ferric hydroxide can be prepared of equally effective character.

COLLOID CHEMISTRY (*Continued*)—

Gels consist of two phases—viz., a solid and a liquid one respectively—and possess great electrical properties which are of importance in the dyeing and tanning industries. Major Bruce has adduced evidence for the belief that a gelatine gel in equilibrium consists of a single phase in the sense of the phase rule (*Inst. Chem. Journ.*, Part vi., 1928, p. 300). H. Bechhold and A. Rosenberg (*J.C.S. Abs.*, 1925, ii., 668) have described a method of combined ultra-filtration and electro-dialysis whereby colloids such as gelatin and glue may be freed almost completely from electrolytes and dialyzable associated products. (See Emil Hatschek on "Some Reactions in Gels" (*J.S.C.I.*, 1911, p. 256); "Gel Structure," by W. C. Arsem (*B.C.A.*, 1926, A, 473); "Some Properties and Theories of Gels," by Emil Hatschek (*Chem. and Ind.*, 1929, **48**, 389); and D. Deutsch on "Phenomena in Gels as Properties of Liquids showing Viscosity Anomalies" (*B.C.A.*, 1930, A, 1369); and Colloidal Silica, p. 807.)

"Sol" is the name given to a colloidal solution from which a "gel" is obtainable—in fact, a "sol" becomes a "gel" when its degree of dispersion is so decreased that it passes beyond the lower limits characteristic of the colloidal solution. Many substances may be prepared in the form of colloidal solution, as, for example, the hydroxides of aluminium, iron, chromium, and tungstic acid, all of which can be coagulated by addition of an electrolyte or certain soluble salts.

"Sols" of gold, silver, and platinum can also be obtained. (See Platinum (Colloidal), p. 718.) Of course, these gels and sols, like other chemical bodies, are susceptible of change—for example, a 0·1 per cent. sol of tungsten is entirely transformed into tungstic acid on keeping for three months (Lottermoser and Riedel, *B.C.A.*, 1930, A, 1113). Colloidal substances capable of stabilizing a sol against coagulation are known as protective colloids.

Colloidal platinum has been prepared and colloidal gold can be prepared by adding a dilute solution of potassium carbonate to a dilute solution of gold chloride, then heating, and, as it begins to boil, adding a small quantity of a dilute solution of glucose. Upon continuing the boiling the mixture becomes violet, and shortly afterwards turns to a brilliant purple. It can also be made by heating a solution of gold chloride with formaldehyde. (See Purple of Cassius.)

The majority of colloidal solutions exhibit opalescence when a powerful beam of light is passed through them, and the individual particles in suspension (the disperse) can be seen by the microscope, although in some cases they will pass through the finest filter paper, and cannot be discerned even with the ultra-microscope, so that there is no hard-and-fast line between colloidal and crystalloid solutions, the particles where discernible being always in motion essentially the same as the "Brownian" movement, which has been described as one of molecular bombardment of the surrounding water.

As to the character of the "Brownian" molecular motion, see E. Samuel (*B.C.A.*, 1930, A, 1115).

"Hydrosols" are colloids having water as the dispersion medium,

COLLOID CHEMISTRY (*Continued*)—
and exhibiting a gradual transition in properties from coarse suspensions through "sols" to true solutions as ordinarily understood.

An "aerosol" is a disperse system of unstable nature consisting of a solid or liquid substance dispersed in a highly subdivided form in a gas, as, for example, smoke. (See W. E. Gibbs on "Aerosols in Industry," *J.S.C.I.*, 1926, **45,** 177 T and 183 T.)

"Suspensoids" are "sols" in which the disperse phase is solid, and "emulsoids," such as solutions of gelatin, are "sols" in which the disperse phase is liquid. Emulsoids and gels as a rule retard chemical action.

"Peptization" is one way of transforming a gel with a sol; otherwise, means of preventing sedimentation of precipitates or bringing otherwise insoluble substances or gels into colloidal solution; also described as dispersion of agglomerates of colloid particles caused by the solution pressure brought about by the added substance. Thus the hydroxides of iron, nickel, thorium, mercury, and cobalt are all "peptized" by adding a caustic alkali to the solutions of salts of those metals in the presence of glycerol or sugar. (See A. V. Slater on "Peptization," *J.S.C.I.*, 1925, **44,** 499 T.)

"Cataphoresis" is a term used to indicate the migration of sols towards the anode or cathode when the medium is under the influence of an electric charge.

"Lyophile colloid systems" exhibit a marked affinity between the disperse system and the dispersion medium, while the reverse is known as the "lyophobe" system.

The major part of the hydroxides of aluminium, chromium, lead, mercury, and copper, when dissolved in potassium or sodium hydroxide, exist in a colloidal state. In an electric field, ferric hydrate in colloidal solution is attracted by the negative pole and that of arsenious sulphide by the positive pole when two wires from a battery are passed therein, so that it is thought they carry the opposing electric charges respectively.

"Sorption"—This term is used rather indiscriminately, sometimes in the sense of adsorption, absorption, etc., and at others as indicative of combination or attachment of water or other liquid in substances of colloid or coagulated character. The McBain-Baker sorption balance is described (*B.C.A.*, 1926, A, 493).

"Adsorption"—This term indicates exhibitions of surface energy by which certain constituents of dissolved solids or gases are concentrated upon the liquid or solid absorbing agent. It has been shown that glass walls of vessels, as also those of silica and platinum, have power of adsorption of some gases such as sulphur dioxide. (See S. Lenher, (*J.C.S.*, 1927, p. 272, and J. W. Smith, *J.C.S.*, 1928, p. 2045.) In its most general sense, the term implies the unequal distribution of a substance at the boundary between two heterogeneous phases, and when these concern a solid and a gas it is usually referred to as "gas adsorption." Practically, it means the removal or abstraction of a constituent of gases or liquids, as, for instance, the removal of iodine from a solution of it in potassium iodide by means of charcoal; or, again, the surface

COLLOID CHEMISTRY (*Continued*)—

action illustrated by the condensation of hydrogen gas by means of palladium, and the retention of the dark colouring matter of crude sugar solutions as effected by filtration through charcoal.

Adsorption substances, such as charcoal and caramel, or charcoal and litmus, do not resemble ordinary chemical compounds in constancy of composition and more or less resistance to decomposition by physical agencies, and are generally formed at the surfaces, the quantity being proportional to the active surface, increasing with increased pressure and decreasing with increased temperature.

W. E. Gibbs has expressed the view that "the surface of every liquid or solid possesses free energy," but this is only equivalent to saying that these substances exhibit the power of chemical interaction. (See *Chem. and Ind.*, 1929, **48,** 127.) The chemical importance of surface tension and internal friction of liquids is summarized by L. Lorenz, who also gives a full biography of the subject (*B.C.A.*, 1930, A, 1097). Surface tension measurements formed part of the subject matter of H. B. Baker's Presidential Address to the Chemical Society (*J.C.S.*, 1927, pp. 949-958). The "Traube Stalagmometer" is an apparatus for the determination of surface tension by the "drop" method.

The relative adsorptive powers of various kinds of charcoal depend not merely upon their respective capacities to absorb gases, but also upon their power of retaining them at reduced pressures.

The initial rate of absorption at 20° C. of a purified cocoa-nut charcoal in respect of some fourteen liquids, in accordance with the laws of diffusion, has been found by F. G. Tryhorn and W. F. Wyatt to be proportional to the vapour pressure of the liquid and inversely proportional to the square root of its molecular weight.

As already pointed out, adsorbents can be prepared from certain colloidal solutions: thus silica gel prepared from a colloidal solution of silicic acid is stated to exhibit a power of adsorption equal or superior to that of animal charcoal. It can be prepared from silicate of sodium by the action of a dilute mineral acid, and is stable in the air even at high temperatures. Sulphur dioxide at a concentration of 0·5 per cent. in air, and with a time contact of 0·8 second, is stated to be adsorbed by it to the extent of 100 per cent., and this new material has proved very valuable in a number of industrial operations for effecting the selective separation of mixed gases and the saving of solvents. (See Colloidal Silica, p. 807.)

See W. Clayton on "Colloid Chemistry of Technical Froths and Foams" (*Ind. Chem.*, 1925, i., 489); Richardson and Robertson on "The Cryoscopic Method for Adsorption" (*J.C.S.*, March, 1925, cxxvii., 553); A. V. Slater on "Adsorption" (*Chem. and Ind.*, 1925, **44,** 161); "Industrial Colloids" (*C.T.J.*, 1928, **83,** 521); Vapour Absorption and Adsorption (subject of a Conference) (*Ind. Chem.*, 1929, **5,** 534); S. C. Bradford on "Absorptive Stratification in Gels" (*Chem. and Ind.*, 1929, **48,** 78); W. E. Gibbs on "Surface Energy" (*Chem. and Ind.*, 1929, **48,** 127-137); "Surface Energy and Chemical Engineering" (*Ind. Chem.*, 1929, v., 447 and 509; 1930, vi., 78, 113, and 273);

COLLOID CHEMISTRY (*Continued*)—

H. Freundlich on "Surface Forces and Chemical Equilibrium" (*J.C.S.*, 1930, p. 164); report of paper by E. K. Rideal (*Chem. and Ind.*, 1930, **49,** 77); Dhar and Chatterji (*Ibid.*, 1929, **48,** 878); "Coagulation," by G. Wiegner (*J.S.C.I.*, 1931, **50,** 55 T); "Technical Colloids," by M. Perrin (*Ind. Chem.*, 1931, vii., 296, 333, and 414); *cf.* Taylor (*J. Amer. C.S.*, 1931, **53,** 578); Taylor and Williamson (*Ibid.*, 1931, **53,** 813); *The Chemistry of the Colloidal State,* by J. C. Ware (Chapman and Hall); *The Parachor and Valency,* by S. Sugden (Routledge and Son, London); *The Principles of the Phase Theory,* by D. A. Clibbens (Macmillan and Co.); *The Phase Rule and its Applications,* by A. Findlay (Longmans); R. H. Bogue's work on *Colloidal Behaviour* (McGraw-Hill Book Co.); Freundlich's *Capillary and Colloid Chemistry,* translated by H. S. Hatfield (Methuen and Co.); *Chemistry of Colloids* (Spears' translation), by R. Zsigmondy (Chapman and Hall); *Physics and Chemistry of Surfaces,* by N. K. Adam (Oxford University Press); *Colloid Chemistry,* by Jerome Alexander (Chapman and Hall); *Colloid Aspects of Food Chemistry and Technology,* by W. Clayton (J. and A. Churchill); and *Surface Chemistry,* 2nd edition, by E. K. Rideal (Cambridge Univ. Press).

(See also Capillary Attraction, Catalysis, Crystals, Dialysis, Emulsions, Enzymes, Occlusion, Osmosis, and Pectographs.)

"COLLOIDAL FUEL" (Liquid Coal)—An emulsified mixture of very finely divided coal and mineral oil. One such recommended mixture is 30 per cent. coal, 10 per cent. coal-tar distillate, and 60 per cent. mineral oil, the properties of which, such as sp. gr. heat value, and viscosity, are proportional to the respective amounts of the ingredients. Where "slack" or powdered anthracite coal, coke, or pitch is available and cheap, such mixtures may be usefully employed in place of ordinary coal. Powdered dry coal is very mobile, and when suspended in fuel oil it can be passed through an ordinary fuel oil burner, but it is apt to separate on standing, and to overcome this, recourse is had to the use of a so-called "fixateur"—that is, a substance which keeps the coal dust in more or less permanent suspension. To obtain the best results, the carbonaceous matter should be ground so fine that 97 per cent. will pass through a 100-mesh screen, and at least 85 per cent. through a 200-mesh screen. The flash-points of most such fuels vary from 250° to 280° F. (See J. G. King, *J.S.C.I.*, 1927, **46,** 181 T; also Berginization, Fuel, Liquid Fuel and Coal.)

COLOCYNTH—The dried fruit of a creeping plant known as the "bitter apple" (*Citrullus colocynthis*), growing chiefly on the shores of the Mediterranean and cultivated in Spain, Cyprus, Syria, and India. An extract made from the pulp is largely used in medicine as a purgative—either alone or in combination with other drugs. It contains as its active principle a very bitter substance named "colocynthin," which appears to have the character of a glucoside.

COLOPHONY—See Gums and Resins.

COLORIMETERS (Tintometers)—Instruments (such as "Lovibond's tintometer,") used for making a comparison between the colours or depth of tint of a column of liquid with that of a prepared standard solution or with standard coloured glasses. There is a more scientific method based upon the measurement of the depth of the coloured solution required to absorb one-half or some other definite fraction of the light at three or four selected parts of the spectrum, such as red, yellow, green, and blue. The "B.D.H." capillator is an appliance claiming to provide an improved method for colorimetric determinations, while the Kodak Research Laboratories have, it is stated, produced one by which all colours can be given an identification number, so that any required hue can be reproduced at any time. The "Toussaint" is a very delicate and exact photometer which serves as a colorimeter, its main feature being its freedom from errors frequently associated when the eye alone is used for comparison of colours, its operation depending upon the use of a specially constructed photo-electric cell. (See *C.T.J.*, 1930, **86**, 266.) An easily constructed form of micro-colorimeter is described by G. W. Chapman (*Analyst*, 1930, **55**, 443). For description of the "Eastman Universal Colorimeter," see *Nature*, 1926, **118**, 30; that of a new colorimeter for the testing of cod liver oil and other purposes, by O. Rosenheim (*Biochemical Jl.*, **21**, No. 6, 1927); a colorimeter for wort is described by Felix and others (*B.C.A.*, 1928, B, 686); a simple form is described by R. C. Frederick (*Analyst*, 1927, **52**, 469); and another variety described is the "Kober" (*Jl. Inst. of Chem.*, Part 2, 1928, p. 100). See also C. Digaud (*B.C.A.*, 1931, A, 593); *Photometric Chemical Analysis*, by J. H. Yoe (Chapman and Hall, Ltd., London); and Tintometers.

COLOUR—Colour results from the breaking-up of light waves, and if the long waves constituting red be removed, blue colour results, while from the removal of the medium waves of yellow and green, purple results, the absorption of colour being due to the absorption of particular wave lengths. Its constants have been described by C. W. Gamble as hue, purity, and luminosity (*Chem. and Ind.*, 1927, **46**, 126).

As occurring in nature, colour may be produced by pigments—definite coloured chemical substances—or by the interference of light by means of fine hairs or filaments. Colours of flowers are examples of the first-named class, while the brilliant colours of peacock's feathers, butterfly wings, and the blue sky are due to the dispersion of white light by physical conditions of the materials. (See *Chem. and Ind.*, 1925, **44**, 628; also Light.)

Apparent colour varies to some extent according to the quality and method of illumination, and L. C. Martin has suggested that a standardized light should be that used by the National Physical Laboratory—viz., a parallel beam of white light incident at an angle of 45° to the normal—and that the surface should be viewed at right angles to the surface.

The "Lumina" daylight spectacles are designed for use at a certain distance from a shaded, 200-watt, gas-filled lamp, and are very useful in colour matching of dyed and other materials.

COLOUR (*Continued*)—

The fastness of a dye or pigment can be determined graphically by plotting time as abscissæ, and the corresponding shade according to the Ostwald scale as ordinates. Curves of a similar nature are obtainable by illuminating with sunlight or with a "Uviol" (mercury) lamp. (See H. Wagner, *B.C.A.*, 1926, B, 166, and *C.T.J.*, 1927, **81**, 418; a "Theory of Colour on the Basis of Molecular Strain," by S. Dutt (*J.C.S.*, 1926, p. 1171); O. D. C. Pierce on "Human Factors in Colour Judgments" (*Chem. and Ind.*, 1931, **50**, 47); and *Dictionary of Colour,* by Maerz and Paul (McGraw-Hill Publishing Co.); Colouring Matters, Dyes, Lakes, Plant Colouring Matters, and Silk Substitutes.

COLOURING MATTERS—Cochineal, indigo, madder, logwood, brazilwood, safflower; the colouring principles of the damask rose, the poppy, turmeric, litmus, and red cabbage are still employed industrially, but the synthetic coal-tar colours have largely superseded the natural vegetable colours. (See Dyes, Lakes, Paints, and Plant Colouring Matters.)

COLUMBITE (**Niobite, Tantalite**)—A mineral of sp. gr. 5·25 to 6·5 and crystal system, No. 4. (See Niobium.)

COLUMBIUM (Cb)—See Niobium.

COLZA OIL—See Rape-Seed Oil.

COMBINING PROPORTIONS—See Chemical Compounds.

COMBUSTION—The amount of heat given out by the combustion of a substance, whether rapid or slow, is the same when the product or products are identical, and is usually expressed in calories per gram-atom or gram-molecule. When carbon, for example, is burned into CO_2, the heat of combustion of 12 grams is 96·980 calories. A simplified method of micro-combustion is described by C. Funk and S. Kow (*J.C.S.*, 1925, cxxvii., 1754); see Obituary Notice *re* H. B. Dixon (*J.C.S.*, 1931, pp. 3352-3362); also *Gaseous Combustion at High Pressures*, by Bone, Newitt and Townend (Longmans, Green and Co., London); *The Theory and Practice of Combustion*, by Lister and Harris (E. Benn, Ltd., London); also Air, Flame, Furnaces, Ignition, Organic Analyses, Oxidation, Steam, and Submerged Combustion.

COMPRESSING PLANT—See article on "Recent Designs in Compressing Plant" (*Chem. and Ind.*, 1929, **48**, 591); Pumps and Pressure (High).

CONCENTRATION—Strengthening a solution by evaporation, or by dissolving more of the solute in it. An alignment chart by S. Cottrell is described in the *C.T.J.*, 1926, **78**, 693. (See Solution.)

CONCRETE—Many varieties of concrete are made, but the constituents are always cement, a fine aggregate (usually sand) and a coarse one (usually pebbles or broken stones or breeze), the purpose of the fine material being to save cement by filling up more closely the pore spaces.

Experience has shown that the strength secured from the cement used is largely dependent upon the quantity of mixing water (varying

CONCRETE (*Continued*)—

from 5·5 to 7·5 gallons per bag of cement), according to the strength required—the ratio between it and the cement used, the size and grading of the aggregate determining the amount of water wanted. (See *Chem. and Ind.*, 1927, **46,** 975.)

Portland cement concrete should not be mixed and placed in frosty weather, as freezing immediately after casting, effects a very deleterious loss of strength. If the gauging water freezes after the "initial set" has occurred, the expansion of ice crystals forces the young crystals apart, and they will not reunite, so that the concrete has no strength and is ruined. It is claimed that the chemical action of "Ciment Fondu" is so rapid that when once the "initial set" has taken place the concrete made with it becomes warm and can therefore be laid in severe frosty weather.

For rapid work, concrete is now frequently mixed in a gravity machine or some similar device and tamped in a very fluid condition. A comparatively dry mixture rammed hard for a long time will give, when set, a dense mass, which will prove harder and less porous than a similar mixture lightly tamped with a larger quantity of water. With respect to the character of water for concrete mixing, see article by Duff. A. Abrams (*C.T.J.*, 1925, **76,** 295); and as regards the admixture of calcium chloride with the cement used for making concrete see *C.T.J.*, 1931, **89,** 306. Concrete is largely employed in constructional work, road-making, also for making storage tanks for various oils, brine, and such other chemical liquids as have no action upon it.

The imperviousness to water and resistance to chemical agents are largely dependent on the closeness of texture of the concrete. Among the various waterproofers used are fats, soaps, partly carbonated lime with aluminium and calcium soaps in aqueous paste form and aluminium soaps and fats in admixture with paraffin oil. Concrete impregnated with injected molten sulphur is stated to be practically impervious, much stronger, and has found use in the construction of large electrolytic cells. (See H. C. Toy on "Permeability of Concrete" (*B.C.A.*, 1925, B, 960).)

Reinforced concrete is made by embedding steel or other material to increase the strength; the deficiency of tensile strength of the concrete is compensated by the steel, the expansions and contractions effected by varying temperatures being for practical purposes identical.

There are several special varieties of sodium silicate, one of which contains 3·3 molecules of silica (SiO_2) to 1 molecule of soda (Na_2O) prepared for facing the surfaces of concrete so that the pores are filled to a depth of from $\frac{1}{4}$ to $\frac{1}{2}$ inch, thus giving an intensely hard outer layer. Fluosilicates of zinc and magnesium are also used in order to produce insoluble face products on the surface.

Blast-furnace slag can be employed as a substitute for gravel and sand in making concrete, and it is said that the resulting product is stronger than that made by using Rhine sand in Germany.

"Spun" concrete compacted with centrifugal force is made for pipes subjected when in use to internal pressure, and thus to tensional stresses. To get the best results, concrete should be allowed to set

CONCRETE (*Continued*)—
in a continuously moist state, and for this purpose calcium chloride in powdered form is advocated, using from 2 to 2½ lbs. spread over the road per square yard on account of its deliquescent nature. Used also to the extent of some 3 per cent., it can be mixed with cement in the making to secure a quicker hardening and increased compressive strength. (See D. A. Adams, *B.C.A.*, 1925, B, 172.)

A light-weight concrete devised by Axel Eriksson (a Swedish architect) is made from cement and shale lime, to which is added a small quantity of aluminium or zinc powder. When placed in contact with water, hydrogen is generated and the mortar thus sets in a porous state. Mortar of 40 parts cement and 60 of lime, with a porosity of 75 per cent., is stated to harden into concrete weighing from 40 to 50 lbs. per cubic foot, and having after a few weeks a compressive strength of 350 to 400 lbs. per square inch. It resists weathering, and can be used in walls of 6 to 8 inches thickness in house construction of one and two stories, but is not suitable for chimneys. "The Determination of Cement Content of Concrete" is the subject of a paper by A. K. Light (*J.S.C.I.*, 1930, **49,** 77 T); see also Bulletin No. 16 and others on the testing of concrete, issued by the Structural Materials Research Laboratory, Lewis Institute, Chicago; Cement, Chemical Plant, "Ferrocrete," Prodorite, and Sodium Silicate (p. 837).

CONDENSATION—Apart from its ordinary meaning, this term has special interpretations in organic chemistry—viz., to indicate the condensation of two or more molecules into one, or the formation of a new body by various classes of interaction, attended generally with the separation of either water, alcohol, ammonia, or hydrochloric acid, etc. Acetic anhydride is, for example, a condensed compound derived from acetic acid by the elimination of water:

$$2C_2H_4O_2 - H_2O = C_4H_6O_3.$$

Among condensation reactions are those known as the "Aldol," "Claissen's," "Friedel-Craft's," and "Grignard." (See "Friedel-Craft's" Reaction, Formaldehyde, and Gums and Resins (Synthetic).)

"CONDENSITE"—A synthetic product prepared from phenol and formaldehyde. (See Bakelite and Gums and Resins (Synthetic).)

CONDUCTIOMETRIC TITRATIONS—See N. Rae (*J.C.S.*, 1931, p. 3143) and Volumetric Analyses.

"CONDY'S FLUID"—A proprietary liquid disinfectant containing sodium permanganate.

CONGELATION—The solidification of liquids by cooling or freezing.

CONGO RED—Prepared from tetrazotised benzidine and naphthionic acid, and supposed to have the structure benzidene-diazo-naphthionic acid; used as a dye and as an indicator in chemical analysis. For account of its manufacture see C. Whitehead (*C.T.J.*, 1925, **77,** 386); see also Dyes.

CONIFERIN—See Glucosides.

CONIÏNE (Conine)—See Hemlock.

CONSERVATION of matter and energy as concrete propositions are not affected by the physical investigations relating to the constitution of atoms and radioactivity.

CONSISTOMETER—See Oils.

CONSOLUTE—Term descriptive of liquids perfectly miscible in all proportions.

CONSTANTS (Physico-Chemical)—Determined values of chemical substances, such as atomic weights, vapour densities, specific gravities, melting- and boiling-points, the saponification and iodine values of fats and oils, etc. The physical and chemical constants of chemical entities depend, not only on their chemical purity, but naturally upon the peculiar physical form in respect of which such determinations are made. For example, the densities of pure white and grey tin respectively are 7·285 and 5·765. Again, Baker has demonstrated the variability of the boiling-points of many fluids, according to the duration of intensive drying to which they have been exposed, so that many so-called constants have to be accepted with careful understanding. (See Critical Constants; reference to intensive drying under heading of Heat, p. 436; and *Physical and Chemical Constants,* by Kaye and Laby (Longmans, Green and Co., London).)

CONSTANTS (Critical)—See Critical Constants.

CONTACT ACTION—See Catalysis.

CONVEYOR DRIVES AND GEARING—See E. C. Hatcher (*Chem. and Ind.*, 1927, **46,** 1063).

CONVOLVULIN—A glucosoidal resin, having purgative properties, contained in the tuberose of the *Convolvulus schiedanus* (Zucc.). (See Jalap and Gums (Scammony).)

"COOPERITE"—A proprietary non-ferrous alloy, containing zirconium, molybdenum, tungsten, silicon, and aluminium, stated to be very efficient for making machine tools, iron being replaced by nickel as a basic constituent for tool production.

CO-ORDINATION—A theory of the structure of molecules or, in other words, the arrangement of atoms in chemical entities resulting from the functioning of valencies—that is to say, the exercise of unsatisfied affinities. In other words, molecules (to use the definition given by J. Main Smith) are regarded as "spatial complexes consisting of atoms closely bound to a central atom," and these spatial considerations are regarded as affording an adequate explanation of general and optical isomerism. According to Werner's theory of "residual valencies,"

CO-ORDINATION (*Continued*) —

seven types of isomerism are possible. According to Lowry there are two types:

"(1) Centric co-ordination, in which the principal factor is the formation of a shell of electrons round a metallic atom; and

"(2) Cyclic co-ordination, in which the principal factor is the development or completion of a conjugated ring system by the insertion of a metallic ion."

Co-ordination is regarded otherwise as the result of an attraction between ions similar in origin and geometrical effects, to the forces which bind together the ions in crystals, such as rock salt. (See G. T. Morgan (*J.C.S.*, 1920, **117,** 1639); E. B. R. Prideaux on co-ordination (*Chem. and Ind.*, 1925, **44,** 25); N. V. Sidgwick on "Co-ordination Compounds" (*Chem. and Ind.*, 1927, **46,** 799); S. H. C. Briggs on "Symmetry" (*Chem. and Ind.*, 1929, **48,** 108); and *Chemistry of the Inorganic Complex Compounds,* by R. Schwarz (Chapman and Hall); Assymmetry, Atoms, Bohr's Theory, Chelation, Chemical Affinity, Isomerism, and Valencies.

COPAIBA OIL—The volatile oil contained in balsam (oleo-resin) of copaiba (capivi) to the extent of some 40 to 65 per cent. It belongs to the class of terpenes; is colourless or pale yellow, of aromatic odour, soluble in alcohol, ether, etc., and finds some use in medicinal practice; sp. gr., 0·895 to 0·918 at 15° C.; ref. ind., 1·493 to 1·502 at 25° C.; opt. rot., $-4°$ to $-35°$, according to variety. The balsam is obtained from incisions made in the trunks of several species of *Copaifera* (N.O. Leguminosæ), indigenous in Brazil and other parts of South America, New Granada, and Venezuela; yield 45 per cent. African copaiba is different, and comes from a species of *Hardwickia,* and Gurjan balsam from species of *Dipterocarpus* (India and Burma); yield 65 per cent. (See Balsams (Copaiba).)

COPAL GUM or RESIN—See Gums and Resins.

COPAL OIL—A fatty oil (huile m'Pafu) from the Belgian Congo, stated to have a sp. gr. of 0·9165 at 19·5° C., sap. v. 196·2, and i.v. 59·5. It is non-drying, and likely to be of use for soap-making.

COPPER (Cuprum) (Cu) and its Compounds—Atomic weight, 63·557; sp. gr., 8·65 to 8·95; m.p., 1,083° C.; credited with isotopes 63 and 65. There are about 240 copper-bearing minerals. It is found in nature in crystalline form (octohedra, crystal system, No. 1); in large masses near Lake Superior (U.S.A.), and in some Siberian mines, while Katanga in the Belgian Congo ranks among the great producers. It also occurs in nature in the form of *copper pyrites* (*chalco-pyrite*), a double sulphide of copper and iron ($Cu_2S.Fe_2S_3$), the Rio Tinto, Mason, and Barry ores being of this description. The Arizona deposits of ore contain up to 1·4 per cent. copper, and those of Utah about 1·1 per cent., and both are worked economically.

Copper ore occurs in Australia and the Urals as *malachite,* a basic carbonate ($CuCO_3,Cu(OH)_2$); in Cuba as an oxide called *ruby ore* (Cu_2O), also as *copper glance,* or sulphide (Cu_2S), in Arizona, Nevada,

COPPER (*Continued*)—

and Cornwall; while the Chile ore of that description is associated with a valuable proportion of silver.

Azurite (*chessylite*), a blue basic copper carbonate of sp. gr. 3·5 to 3·8, and of crystal system, No. 5, occurs at Chessy near Lyons, and has the composition expressed by the formula $2CuCO_3,Cu(OH)_2$.

Atacamite, $CuCl_2.3Cu(HO)_2$, a basic chloride of sp. gr. 3·75 to 4·3, is found in light green crystalline form (crystal system, No. 4) in the district of Atacamite in Peru and elsewhere, while the green portion of the incrustation on Vesuvian lava has been given the same composition (G. Carobbi, *B.C.A.*, 1929, B, 289).

Olivenite is a crystalline arsenate (crystal system, No. 4, and sp. gr. 4·13 to 4·38) of the composition of $4CuO,As_2O_5,H_2O$.

Berzelianite is a copper selenide ore.

Brochantite, $CuSO_4,3Cu(OH)_2$, and *Antlerite*, $CuSO_4,2Cu(OH)$, are two naturally occurring basic sulphates.

Tetrahedrite or *grey copper ore* is a compound ore, containing the sulphides of copper and antimony with about 52 per cent. copper (crystal system, No. 1, and sp. gr. 4·5 to 5·0).

Cuprite is a red oxide ore of the composition Cu_2O (crystal system, No. 1, and sp. gr. 5·8 to 6·2), and this, together with cupriferous pyrite, are the minerals most commonly found. These latter are converted into sulphates by oxidation, and are often concentrated by a leaching process in a zone of rich oxide below.

Chalco-pyrite is found abundantly in the United States, and good concentrates are obtained from this mineral by the selective flotation process. (See also Chalcanthite and Redruthite.)

The world's production of copper in 1929 was about 2,000,000 tons, of which the British Empire share was 100,000 tons, Canada being the chief contributor to that amount, its production in 1930 having been 303,478,356 pounds. More than one-half of the total came from the U.S.A., chiefly Utah, and the consumption is continually increasing.

Large deposits of copper ores containing from 3 to 5 per cent. occur in Northern Rhodesia. (See article on "The Copper Resources of British Africa" (*Chem. and Ind.*, 1930, **49**, 721) and *The Times* on "Empire Copper," February 9 and 10, 1931.)

When the oxide of copper is used for production of the metal, it is smelted in a blast-furnace with coal or coke, by which it is reduced as shown by the equation: $Cu_2O + C = CO + 2Cu$; that is to say, the oxygen of the cuprous oxide enters into combination with the carbon of the coal or coke, forming carbon monoxide, and the metallic copper thus produced is afterwards refined by other processes. With other ores of copper containing sulphides, the sulphur content has first of all to be roasted off as sulphur dioxide, and consequently different processes are necessary. A direct electrolytic method for obtaining the metal from its sulphide ores is described by R. Saxon (*C.T.J.*, 1925, **77**, 626).

There is a process for the extraction of copper from some of its ores by so-called ammonia leaching, in which the natural sulphide ores are roasted into oxides, and then treated with ammonia solution, thus

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producing a dark blue liquid which upon heating gives off ammonia vapour and carbon dioxide gas, and deposits a heavy black powder consisting in the main of cupric oxide (CuO).

The crude copper "matte," containing from 40 to 50 per cent. copper, obtained by the roasting and reduction processes, furnishes the crude material from which the "blister" copper is subsequently obtained by a remelting process, and this again is further refined by an electrolytic process which yields ingots of 99·9 per cent. purity as used for the metal-working industries. (See article on "Converting Low-grade (Copper) Matte at Rio Tinto," by H. R. Potts (*B.C.A.*, 1929, B. 982).)

The "Lockwood" process for the electrolytic production of copper is one of separation and deposition of the metal from a pulp containing the entire crushed ore with an acid solution, air being forced through the mixture to prevent sedimentation. If the ore be a sulphide, it must first of all be roasted to get rid of the sulphur. The dissolved copper is deposited on the cathode after running by gravity into an adjacent recovery tank, while the weakened acid is regenerated at the anode. It is stated that the time of treatment is so short that fouling materials such as iron do not dissolve in appreciable quantity. About from 80 to 90 per cent. of the world's copper is now obtained electrolytically.

The grades of copper dealt with in Great Britain are "Best Selected" (B.S.), with an average content of 99·75; "Tough," "Tough Pitched," or refined copper containing 99·25 per cent.; "Electrolytic" (the purest of all) and "Standard," meaning any class containing not less than 97 per cent., including "Chile Bars." "White Metal" is a name for matte consisting almost entirely of copper sulphide.

The copper, which is contained (to the extent of about 3 per cent.) in burnt pyrites used in the manufacture of sulphuric acid, is extracted by a wet process in which the residual mass is calcined with salt, which converts the copper into the form of chloride, after which the fused mass is lixiviated with water and the copper precipitated from the solution by means of scrap-iron or by electrolysis. The metal so obtained in a spongy condition can either be smelted, or roasted into oxide, and sometimes the oxide so prepared is subsequently dissolved in sulphuric acid in order to produce cupric sulphate, which can be crystallized out from the solution. A special commutator motor for driving a Ramen-Beskow chloridising furnace for the treatment of cuprous pyrites cinders is described in the *C.T.J.*, 1929, **84,** 610.

Most of the copper-smelting in this country is carried out at Swansea, and its refining is dealt with in an article in the *Ind. Chem.*, 1925, i., 425. The refining and manufacture of copper is the most important metal industry in Japan, the exported quantity being worth about £10,000,000 per annum.

The chemical changes which occur when metallic copper is exposed to the air has recently been the subject of new investigations.

"Verdigris" has frequently been described as a basic copper carbon-

COPPER (*Continued*)—

ate of the composition $CuCO_3.Cu(OH)_2$, but the name is more properly given to basic cupric acetates, one such product having long since been manufactured at Montpellier (France) by exposing plates of copper to the air in contact with acetic acid or fermenting wine-lees. Another form styled "green verdigris" was made at Grenoble by periodically sprinkling copper plates with vinegar in a warm room. These products, which varied in composition with the different modes of procedure and other circumstances, are quite distinct from "Patina"—that is, the green copper compound so often occurring on copper surfaces exposed to the air, and particularly in towns where sulphurous fumes constitute ingredients.

In the past, "Patina" has been generally described as a form of basic copper carbonate, sometimes expressed as having the composition of malachite; but while it is certain that some kind of carbonate may be found under certain conditions, it has been demonstrated by W. H. J. Vernon that the green patina which forms on the surface of copper after prolonged exposure to the air consists under most conditions essentially of basic copper sulphate. At the sea-board it may consist essentially of basic copper chloride. It has also been shown that these open-air corrosion products of copper tend to assume the chemical compositions of known minerals, such as *brochantite* ($CuSO_4.3Cu(OH)_2$), basic copper chloride like that of *atacamite* ($CuCl_2.3Cu(OH)_2$), and basic copper carbonate like that of malachite ($CuCO_3.Cu(OH)_2$). (See *J. Inst. Metals,* 1929, **42,** 181; Vernon and Whitby (*Ibid.*, 1930, **44,** 389); and *Trans. Faraday Soc.*, No. 121, vol. xxvii., part 6, June, 1931, and part 9, September, 1931.)

Copper is one of the most useful metals; has a reddish colour, is rather hard but flexible, tenacious, very ductile and malleable, and, apart from its employment in the form of wire for telegraphic purposes (on account of its excellent conductivity), is largely used for making domestic utensils, coins, sheathing of wooden ships, alloys with cadmium, zinc, and other metals, while with various proportions of tin it forms *bronze, bell-metal, gun-metal, brass,* and "*Muntz metal.*" An alloy of copper and aluminium of golden colour named "*Alcobronze*" is stronger, tougher, and harder than any other known bronze, and capable of resisting the influence of air, acids, and salt water. (See Alloys.) It is weldable by the so-named "Premag Process." Until recently the welding of copper was practically impossible, or at least most unsatisfactory, but it has now been achieved by means of slight modifications in the technique of welding non-ferrous metals by the use of copper alloy filler rod and flux of an appropriate type, the copper being a modification of the "tough pitcher" variety (see *C.T.J.*, 1930, **86,** 427).

The catalytic action of reduced copper varies according to its mode of formation, serving among other processes as a catalyst for the oxidation and dehydration of menthol.

Copper Oxides—There are two oxides of copper, insoluble in water—

COPPER (*Continued*)—

viz., the red cuprous oxide (Cu_2O), which is found native as *cuprite,* and gives to glass a beautiful ruby coloration; and cupric oxide (CuO), which is black and produces blue and green salts by combination with acids. Cuprous oxide suspended in water made alkaline with sodium hydroxide is rapidly converted into cupric oxide by passage of air (Kingzett, *Chem. News*, January 5, 1872). Cupric oxide occurs in a crystalline condition in nature as *red copper ore,* and in the precipitated form is useful as a catalytic agent, also in compounding anti-fouling compositions and paints for ships.

There are a number of copper hydroxides. A solution of the blue hydrated cupric oxide or cupric hydroxide ($Cu(HO)_2$) (as made by interaction of an alkaline hydroxide and solution of a copper salt) dissolved in ammonia is used in the preparation of "Willesden paper" and some silk substitutes, while the hydroxide itself, which is insoluble in water, is used as a pigment. It can be obtained practically pure by the interaction of cuprous iodide with sodium hydroxide, and in this state is insoluble in ammonia. (See *J.C.S. Abs.*, 1925, ii., 318.)

Copper Chlorides—There are two chlorides of copper corresponding to the two oxides, used as mordants, etc. The cuprous chloride (Cu_2Cl_2) is insoluble in water, but the cupric chloride ($CuCl_2$) is readily soluble, giving a deep green-coloured solution.

Cupric Nitrate—A soluble crystalline salt having the composition $Cu(NO_3)_2,3H_2O$ is used in the paper industry and ceramics, etc.

Cupric Sulphate (**Copperas**) ($CuSO_4.5H_2O$)—This important salt of copper occurs naturally as chalcanthite in some Chilian mines, Arizona, and elsewhere, and is formed when the metal or its oxide is dissolved in sulphuric acid ($Cu + 2H_2SO_4 = CuSO_4 + SO_2 + 2H_2O$). The world production in 1928 was reported as 237,000 metric tons, of which Italy produced about 100,000 tons and Great Britain and N. Ireland 50,000 tons. As prepared by the leaching of copper ores with sulphuric acid, the product requires purification from ferrous and ferric sulphates and other impurities. (See G. S. Tilley and O. C. Ralston, *J.S.C.I.*, 1925, **44**, B, 446.) It is soluble in water, and the solution yields by crystallization fine blue crystals containing 5 molecules of water. Its dehydration is the subject of a paper by Garner and Tanner (*J.C.S.*, 1930, p. 47), and a description of its manufacture as conducted at the Clydach Works is given (*Engineering*, September 19, October 3 and 10, 1930). It is used as a mordant in dyeing, in the manufacture of "Scheele's green," "Brunswick green," and other pigments, in electric batteries, and in preparing a number of compounds used for the destruction of snails and slugs, and low forms of insect pests on vines and other plants. A preparation sometimes used to combat these insect pests is a 2 per cent. solution in lime water. (See Bordeaux Mixture.) In addition to the two natural basic sulphates, others have been described, including one of the composition $4CuO,SO_3,4H_2O$. (See R. Freitag on "Copperas Manufacture," *C.T.J.*, 1931, **89**, 221.)

COPPER (*Continued*)—

Copper Sulphides—There are two sulphides of copper corresponding to the two oxides—the cuprous sulphide (Cu_2S), being identical with the mineral known as crystalline *copper glance*; and cupric sulphide (CuS), which is chemically identical with the mineral *indigo copper*—and both are used as protective paints on ships.

Copper Hydrides—Two hydrides—viz., CuH and CuH_2—have been described, but a recent investigation has made the existence of the latter compound doubtful. (See Müller and Bradley, *J.C.S.*, 1926, p. 1669.)

Scheele's Green ($CuHAsO_3$) (sometimes described as copper-hydrogen arsenite) is of bright green colour, and used as a pigment and insecticide. It is made by mixing solutions of cupric sulphate and sodium arsenate, or by dissolving arsenious oxide (As_2O_3) in potassium carbonate solution and adding to it a solution of copper sulphate in water. Its composition is said to vary with the method of preparation, the proportion of CuO being larger in proportion to the excess of alkali used. According to one report, Scheele's green is a neutral hydrous copper arsenate of the formula $3CuAs_2O_3 \times H_2O$, and not $CuHAsO_3$, and differs from emerald green in not containing any copper acetate. (See Paris Green, below.)

Brunswick Green is a pigment (copper oxychloride) made by moistening copper turnings with a solution of ammonium chloride (sal ammoniac), and exposure to the air.

Paris Green (**Schweinfurt Green**)—Copper aceto-arsenite, represented by the formula $3CuOAs_2O_3.Cu(C_2H_3O_2)_2$, is an emerald-green pigment prepared by boiling basic acetate of copper with arsenic trioxide. It may also be prepared by mixing verdigris with a solution of arsenious acid acidified with acetic acid, but is ordinarily made by adding sodium arsenite and sodium acetate to an acetic acid solution of copper sulphate. (See *C.T.J.*, 1925, **77**, 266.) It is used as an insecticide for spraying fruit trees infested with caterpillars and destruction of the larvæ of "leather jackets."

Emerald Green—A pigment, being a combination of metarsenite and acetate of copper ($3Cu(AsO_2)_2,Cu(C_2H_3O_2)_2$). (See also V. N. Schultz (with others), *B.C.A.*, 1931, B, 403.)

Cupric Acetate ($Cu(C_2H_3O_2)_2H_2O$)—A greenish-blue crystalline body, soluble in water and alcohol, which finds employment as an insecticide, in ceramics, in preparing ships' bottoms composition, and in printing fabrics.

Copper Basic Acetate—See p. 238.

Copper Borate ($CuBO_4$)—A crystalline substance soluble in water; used as a pigment.

Copper Carbonates—Two carbonates are known, one of which is identical in composition with native *malachite* ($CuCO_3(OH)_2$), and another identical with azurite ($2CuCO_3,Cu(HO)_2$), both of which are insoluble green powders used not only as pigments and as driers in oil-boiling, but also as insecticides (by dry spraying).

COPPER (*Continued*)—

A stable basic carbonate ($2CuO,CO_2$) is formed by the intermixture of a cupric salt and a soluble carbonate.

Cupric Chlorate ($Cu(ClO_3)_2 6H_2O$)—A bluish-green, deliquescent, crystalline body, soluble in water (of dangerous character, like most chlorates); used as a mordant.

Cupric Cyanide ($Cu(CN)_2$)—A green powder, insoluble in water; used in metallurgy.

Cupric Fluoride ($CuF_2.2H_2O$)—A blue, crystalline salt, soluble in water; used in ceramics and enamels.

Cuprous Phosphide (Cu_3P_2) is a dark, insoluble, metallic-looking powder; used in making phosphor bronze.

Cupric Resinate ($Cu(C_{20}H_{29}O_2)_2$) is a green compound soluble in ether and oils, used as a metal paint—in particular for ships' bottoms.

Copper Ammonium Sulphate ($CuSO_4.4NH_3.H_2O$)—A blue, crystalline, soluble salt; used in calico printing and as an insecticide.

Copper Chromate—A basic insoluble compound ($CuCrO_4.2CuO.2H_2O$) of chocolate colour; used in dyeing.

The salts of copper are poisonous.

COPPER GLANCE—See Copper Sulphides and Redruthite.

COPPER-ZINC COUPLE—An appliance consisting of zinc and precipitated copper deposited thereon, which was used by Gladstone and Tribe in preparing methane from magnesium methyl iodide and in the study of a variety of other chemical changes induced by the couple.

COPPERAS (Blue) ($CuSO_4,5H_2O$)—A common name for cupric sulphate.

COPPERAS (Green) ($FeSO_4,7H_2O$)—A common name for ferrous sulphate.

COPRA—The dried edible part (meat) of the common cocoa-nut, as prepared for the extraction of cocoa-nut oil, of which it contains, when dry, up to 66 per cent. The Ceylon oil contains about 2 per cent. free fatty acids and the Java oil about 4 per cent. Copra-meal is stated to be rich in the amino-acids necessary for the maintenance of growth, and when mixed with green leaves furnishes a fairly perfect food for pigs.

Of the total world's crop of cocoa-nut, about 10 per cent. is produced in the Pacific archipelagos, 16 per cent. in the Dutch East Indies, 15 per cent. in the Philippines, 55 per cent. in Ceylon and continental Asia, 2 per cent. in Africa, and 2 per cent. in tropical America. The copra production in 1922 was estimated at 600,000 tons. (See Cocoa-nut Oil.)

COPROLITES—Imported phosphatic deposits in the nature of extinct animal excrements found in certain geological formations, particularly in the *lias*. They consist chiefly of calcium phosphate and carbonate, the phosphate amounting in some cases to as much as from 80 to 90 per cent., and on account of their phosphatic character they are valuable fertilizers. During the Great War the deposits in Cambridgeshire were mined, but at a cost exceeding the pre-war cost of the

COPROLITES (*Continued*)—
imported products. Phosphate deposits are found in the Society Islands as soil, also in Curaçao, Algeria, the U.S.A., Oceania, and Tunis. (See Apatite, Guano, Phosphorus, and Superphosphate.)

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COQUILHO (**COQUILLA**) **NUTS**—This Brazilian nut (from *Attalea funifera*), which is of large size and used by button makers, possesses a kernel which is stated to yield about 65 per cent. of a non-drying oil, having i.v. 14 and sap. v. of 261.

CORAL—A calcareous substance containing from 95 to more than 98 per cent. calcium carbonate, 0·28 to 0·84 calcium phosphate, and from 1·64 to 3·8 per cent. water and organic matter, forming the hard skeleton of many varieties of some five kinds of organisms—viz.:

Actiniozoa, forming the principal constituents of coral reefs.

Hydrozoa, characteristic of the larger common corals known as millepores; *Bryozoa*, found in the more delicate corals; *Foraminifera* and *Nullipores*.

CORDITE—See Explosives.

CORIANDER OIL—A volatile essential oil of aromatic taste, obtained by distillation with water from the seeds or fruit of the *Coriandum sativum* (indigenous in South Europe and cultivated in England, Russia, Thuringia, Hungary, North Africa, India, etc.). The seeds contain from 0·37 to under 1 per cent. of essential oil, which in a dilute state has the smell of orange flowers, is used for flavouring, and acts as a pleasant but powerful carminative. It contains linalool and pinene, etc., is soluble in alcohol and ether, has a sp. gr. 0·870 to 0·885 at 15° C., opt. rot. +8° to +13°, and ref. ind. 1·4635 to 1·4675 at 20° C. A description of Rumanian coriander oil is given by E. Kopp (*B.C.A.*, 1930, B, 120); see also Vanin and Tschernojarova (*B.C.A.*, 1931, A, 492). The seeds are also stated to contain some fatty oil, described by G. Norkin (*B.C.A.*, 1931, **50**, B, 31).

CORK is the outer bark or cork of the *Quercus suber* tree, which grows in the southern part of Europe, the north of Africa, and in the East, and consists in part of a modified form of cellulose (about 22 to 23 per cent.). According to F. Zetzsche and G. Rosenthal, a substance named suberin is the essential constituent of cork (*B.C.A.*, 1927, A, 541). When oxidized with nitric acid it yields, amongst other products, oxalic acid. Its sp. gr. ranges from 0·215 to 0·24, and increases with age.

Cork dust is used in making linoleum and oilcloth coverings.

CORNELIANS (**CARNELIANS**) (Crystal system, No. 3)—Beautiful variegated quartz stones of the finer varieties of chalcedony, found chiefly in India. (See Chalcedony.)

CORNETITE—The name of a basic phosphate of copper occurring in Northern Rhodesia, and applied also to a basic double phosphate of cobalt and copper found at Katanga (Belgian Congo).

CORN OIL—See Maize Oil.

"CORONDITE"—An abrasive containing crystals of alumina, made by smelting red bauxite with anthracite, and blowing air through the mixture.

"CORONIUM"—A bronze alloy of copper 16 parts, zinc 3 parts, tin 1 part, of which tensile tests have given from 16 to 18 tons per square inch.

"CORRONIL"—An alloy which contains a large proportion of nickel, and has high anti-corrosive properties.

CORROSION—The subject of corrosion covers an enormous field, including the action of gases, liquids, and solids under a great variety of circumstances. Long since, it was shown by Brame that unseasoned oak is capable of evolving sufficient moisture and organic acids to corrode a lead roof.

Ordinary iron and steel are commonly known to be particularly susceptible to corroding influences; so also is copper and many other metals and alloys; even glass is liable to corrosion.

In brief, corrosion is due to chemical action occurring where it is not wanted, and in order to prevent such action in respect of innumerable materials, resort is made to various methods of covering or protecting them with protective materials. Silver plating, gold plating, nickel plating, grease lacquering, painting, varnishing, etc., are instances of these.

In addition to atmospheric, water, and underground corrosions, the subject-matter concerns all the many and varied conditions affecting the behaviour of acids, alkalies, saline solutions, and gases towards metals and other materials. Most cases of surface corrosion are of an electro-chemical character, and so far as the formation of protective coatings is concerned, the subject is dealt with to some extent under the heading of Metal Spraying, etc. W. Palmaer (with some associates) regard the establishment of local E.M.F., and not the occurrence of diffusion phenomena, as the determining factor in the corrosion and dissolution of metals (*B.C.A.*, 1929, B, 921).

Duffek's Rust Apparatus is one that has been devised for use in making corrosion tests of metals, etc., and a description of it will be found in *Ind. Chem.*, 1931, vii., 41.

Other references: Bengough and May (*J. Inst. Metals*, 1924, **32**, 81-256); U. R. Evans on "Water-line Corrosion of Iron and Steel, etc." (*J.S.C.I.*, 1925, **44**, 163 T; 1926, **45**, 37 T; 1927, **46**, 347 T and 363 T; *J.C.S. Abs.*, 1925, ii., 687; and *Chem. and Ind.*, 1926, **45**, 504; *Ibid.*, 1930, **49**, 471-474); U. R. Evans on "An Air Thermostat for Corrosion Research" (*Chem. and Ind.* 1931, **50**, 66); R. J. Baylis (*Ind. Eng. Chem.*, 1926, **18**, 370); C. O. Harvey (*Chem. and Ind.*, 1925, **44**, 1111); P. Parish (*Ibid.*, 1926, **45**, 593 and 612); A. Grounds (*Ind. Chem.*, 1926, ii., 296); H. Seymour (*Ibid.*, ii., 562); S. Wernick (*Ibid.*, 1927, iii., 345 and 433; 1928, iv., 181 and 234; 1929, v., 106 and 524); article, *C.T.J.*, 1926, **79**, 468; H. J. Young (*Ind. Chem.*, 1927, iii., 492); report of "Discussion held by Faraday Society, May 23, 1929" (*Trans. Faraday Soc.*, 1929, **25**, 177 and 475; No. 121, vol. **27**,

CORROSION (*Continued*)—
part 6, June, 1931); J. Mitchell (*C.T.J.*, 1926, **78**, 248); T. H. Burnham (*Ind. Chem.*, 1928, iv., 320); McAulay and Bastow (*J.C.S.*, 1929, p. 85); J. C. Hudson (*B.C.A.*, 1929, B, 684); G. T. Morgan (*Chem. and Ind.*, 1930, **49**, 742); W. S. Patterson on "The Atmospheric Corrosion of Iron" (*J.S.C.I.*, 1930, **49**, 203 T); F. L. Bassett on "Corrosion of Buried Steel" (*J.S.C.I.*, 1931, **50**, 161 T); Vernon and Jordan on "Corrosion and Paint" (*Chem. and Ind.*, 1931, **50**, 1050); reports of the Corrosion Research Committee (Inst. of Metals); *Corrosion: Its Causes and Prevention*, by F. N. Speller (Mc-Graw Hill Publishing Co.); *Corrosion of Metals*, by U. R. Evans (E. Arnold and Co.); *Causes and Prevention of Corrosion*, by A. A. Pollitt (E. Benn, Ltd.); *A Bibliography of Metallic Corrosion*, by W. H. J. Vernon (E. Arnold and Co.). (See also Adeps Lanæ, Metals, Passivity, and Rust.)

CORROSIVE SUBLIMATE—See Mercuric Chloride.

"CORUBIN"—Slag produced in manufacturing chromium by the "Thermit" process, containing about 72 per cent. alumina and 13 per cent. chromium, used as an abrasive in lens grinding. (See Chromium.)

CORUNDUM—See Aluminium, p. 38.

COSTINGS of production in chemical industry. *The Costing of Chemical Manufacturing Processes*, lecture by L. Staniforth (Inst. of Chemistry); A. E. Vago (*C.T.J.*, November 21, 1924); L. Staniforth (*Chem. and Ind.*, 1928, **47**, 1267); abstracts of other papers (*C.T.J.*, November 14 and 21, 1924, with report of discussion); "Statistics in Industry," by H. C. Marris (*Chem. and Ind.*, 1927, **46**, 23); see also Data Sheets.

COTARNINE ($C_{12}H_{15}NO_4$)—A primrose-coloured, crystalline base obtained by the action of nascent hydrogen and subsequent oxidation of narcotine. It is soluble in water and alcohol, and in common with the hydrochloride (stypicinin) is used in medicine.

COTTON—The wool-like product of all the species of the genus *Gossypium* (N.O. Malvaceæ) made from the seeds, and consisting of from 90 to 95 per cent. cellulose. It is cultivated in many countries, including the U.S.A., East Indies, China, Uganda, Egypt, etc., the U.S.A. supplying upwards of one-half of the total production. Cotton seed contains on average 9 to 10 per cent. water, 20 to 23 per cent. oil, 18 to 21 per cent. albuminoids, 22 to 27 per cent. digestible carbohydrates, 17 to 26 per cent. woody fibre, and 4 per cent. mineral matter. The pressed cake has value as a feeding stuff. Cotton fabrics deteriorate in strength by exposure to heat (90° C.) partly as the result of oxidation, while the cellulose and other constituents (which vary in raw material of different origins) are subject to alteration or partial removal by the use of bleaching agents and other technical processes. The "hydrophile" power of cotton (wool) is the speed with which it becomes soaked, and the "absorptive" power is indicated by the weight of liquid retained after immersion under a small definite pressure.

A method of distinguishing cotton fibres from linen fibres by the use of silver nitrate is described by W. Dickson in the *Analyst*, 1925, **50**, 317.

Zinc chloride is largely used on account of its antiseptic property as

COTTON (*Continued*)—

an ingredient in cotton sizing, and, although other agents of greater antiseptic value are more or less available, their use in cotton dyeing is often attended with disadvantages in colour, cost, etc. Recently, salicylanilide under the registered name of "Shirlan" has been patented as a good agent, and is available also in the form of its readily soluble sodium salt, but its value is questioned.

Among the constituents of the benzene extract of American and Egyptian cotton sliver, the principal one in the wax-like product thus obtained is an alcohol termed gossypyl alcohol ($C_{30}H_{62}O$), m.p. 85°, and it is accompanied by smaller proportions of montanyl alcohol ($C_{28}H_{58}O$), m.p. 83·5°, ceryl alcohol ($C_{26}H_{54}O$), carnaïibyl alcohol ($C_{24}H_{50}O$), and a mixture of phytosterols, together with free fatty acids, etc. According to one account, a thorough extraction with benzene yields 0·503 per cent. wax, and after treatment with acid, further 0·058 per cent. A more recent investigation by Lecomber and Probert (*B.C.A.*, 1926, B, 150) of cottons grown in various countries, shows a fat and wax content (carbon tetrachloride extract) varying from 0·34 to 0·54 per cent., and average values of some twenty-seven samples as follows: acid value 26, sap. v. 70, i.v. 23. The ash content ranges from about 1 to 1½ per cent.

So-called "immunized" cotton is obtained by the partial etherification of cotton, and is characterized by its resistance to the usual type of substantive cotton dyestuffs; but by treatment of the product with ammonia an "amidated" variety is prepared which exhibits a remarkable affinity for acid dyestuffs (*C.T.J.*, 1926, **79**, 472). (See also J. T. Marsh (*Ind. Chem.*, 1928, iv., 57).)

Other References: "Fungi causing Mildew in Cotton Goods," by L. D. Galloway (*J. Text. Inst.*, 1930, **21**, 277 T, or abstract in *Analyst*, 1930, **55**, 524); Fargher, Galloway, and Probert (*J. Text. Inst.*, 1930, **21**, 245 T); E. R. Trotman on cotton bleaching (which effects some purification) (*Ind. Chem.*, 1926, ii., 481); M. Freiberger (*C.T.J.*, **83**, 208); A. C. Burns on bacterial deterioration of cotton by damp storage (*J.S.C.I.*, xliv., B, 666); "The Action of Light on Cotton," by H. Kauffmann (*B.C.A.*, 1926, B, 817); "Cotton Dyeing," by E. R. Palmer (*Ind. Chem.*, 1925, i., 398); "The Use of *p*H Control in Cotton Dyeing," by a Dyeworks' Chemist (*Ind. Chem.*, 1929, v., 323); "Testing the Quality of Cotton Cellulose," by A. J. Hall (*Ibid.*, iv., 376); "Tensile Strength and Fluidity of Chemically Modified Cotton," by Glibbens and Ridge (*B.C.A.*, 1929, B, 239); R. H. Kay on "Cotton Cloths" (*Analyst*, 1931, **56**, 647); "Nature of Dust in Cotton Card Rooms" (*Ibid.*, 1931, p. 210); *The Production of Cotton*, by H. G. Collings (Chapman and Hall, Ltd.); and *Chemistry of Cotton Cellulose*, by A. J. Hall (Ernest Benn, Ltd.). (See Cellulose, Cotton-seed Oil, Linen, and Toluene Sulphochloride.)

COTTON-SEED BRAN—The oxidation of this by-product with nitric acid under certain conditions is said to give a product consisting mainly of xylotrihydroxyglutaric acid ($COOH.(CHOH_3)COOH$), intermediate

COTTON-SEED BRAN (*Continued*)—
between tartaric and mutic acids, which appears to be a satisfactory substitute for both tartaric and lactic acids in their applications in the textile industry.

COTTON-SEED OIL—This oil, expressed with the aid of heat from cotton seeds (*Gossypium herbaceum*), is largely used (after hardening) in making margarine and soaps, and in its natural form as a leather dressing and in preparing carron oil. Large amounts of cotton seed come from Korea and North China, which supply the Japanese mills. Supplies also come from Egypt, but the largest amount is produced in the U.S.A.. The Egyptian variety yields about 22 per cent., the Indian about 16 to 18 per cent., the Chinese about 8·5 per cent., and the American about 13 per cent. of oil. Its ref. ind. is 1·4643 at 40° C., sp. gr. 0·922 to 0·927, sap. v. 193 to 195, m.p. 35° to 38° C., and i.v. 105. Cotton-seed oil is refined by steam-heating it with 5 per cent. of a 16° Baumé caustic soda lye and settling, 93 per cent. of refined oil being thus obtained. With respect to a modified refining process see note (*C.T.J.*, 1931, **88**, 592). A published analysis of Sea Island cotton-seed oil shows that it consists of glycerides of the following acids: myristic, 0·3; palmitic, 20; stearic, 2; arachidic, 0·6; oleic, 35·2; and linolic, 41·7 per cent. Upon chilling, it deposits so-called "cotton stearine," composed chiefly of stearine mixed with some other glycerides, and when the stearine has been removed the oil is known as "winter oil," as it does not readily solidify in cold weather. The pressed cake is used as cattle food. The bleaching of cotton-seed oil is effected by means of 6 per cent. fuller's earth.

Most of the protein content of the cotton-seed meal when purified can be extracted at room temperature by a 10 per cent. solution of sodium chloride.

Next to olive oil, the American cotton seed oil is the largest item in edible vegetable oils. The raw cotton contains about 1 per cent. of wax, which can be extracted after crushing by means of benzene.

Cotton-seed oil if used alone produces soft soap.

According to E. T. Webb, 1,100 lbs. cotton seeds yield 177 lbs. oil, and 525 lbs. of cattle feeding cake and meal are recovered (see "Cotton Seed Products," *C.T.J.*, 1911, **49**, 38; also Cotton).

COTTRELL PRECIPITATING PLANT (Lodge-Cottrell Process)—An electrical arrangement for condensing mists and recovering valuable constituents of waste gases. It consists of two sets of electrodes, one connected with a source H.T. potential and another to earth, the shape of the electrodes varying with the conditions of application. The suspended liquid or solid particles contained in the gases passing through the gap between the two become charged with electricity and are condensed, or deposited on the surface of the earthed electrode. This plant can be usefully applied for air-cleaning in workrooms; to cause the condensation of the mist-like fumes generated in the concentration of sulphuric acid; for the recovery of lead from the waste gases of lead furnaces; deposition of the suspended dust in the waste gases from

COTTRELL PRECIPITATING PLANT (*Continued*)—

cement works; deposition of arsenious oxide from the fumes yielded by roasting arsenical ores, and application to practically all kinds of fumes, including the collection of "tar fog" from the gases of gas-producers, coke-ovens, and distillation processes. The process can also be utilized for the fractional precipitation of mixed materials differing in volatility during operations conducted at different temperatures; for example, high-grade white arsenic can be separated from lead fume by the precipitation of lead and zinc compounds while the temperature is high enough to keep white arsenic in a gaseous state, and the latter compound can be obtained by cooling the escaping gas. Smokes, fumes, and dusty gases may all be regarded as disperse systems, the dispersed substances being solid or liquid in a dispersion medium of gas.

Efficiencies of 85 to 99 per cent. in the case of metallurgical fume and 99 per cent. in the deposition of pyrites burner dust by electrical means have been reported by P. E. Landolt, of the U.S.A. Research Corporation. (See Oliver Lodge (*J.S.C.I.*, 1886, p. 572); "Omega" (*C.T.J.*, 1926, **78,** 245 and 435); *C.T.J.*, 1929, **85,** 148; H. W. C. Henderson on "The Application of Lodge-Cottrell Precipitators" (*Ind. Chem.*, 1926, ii., 161); article on "Carbon Tubes in Electrostatic Precipitation Plant" (*C.T.J.*, 1930, **87,** 569); and C. W. Hedberg on "Dust Removal from Industrial Gases," etc. (*B.C.A.*, 1931, B, 725).)

COULOMB—See Electricity.

COULOMETER—See Voltameter.

COUMARIN ($C_9H_6O_2$ or $C_6H_4.O.CO.CH:CH$)—The aromatic principle of woodruff (*Asperula odorata*), contained also in sweet-scented vernal grass and sweet clover (*Meliotus alba* and *officinales*), and in the Tonka bean (the fruit of *Dipterix odorata* in the form of small colourless crystals between the seed coating and the kernel), and being soluble in alcohol it can be easily extracted therefrom. There is reason for thinking it results from the decomposition of a glucoside. In pure state it is colourless, crystalline, of m.p. 67° C., readily soluble in alcohol, ether, and hot water, has an agreeable aromatic odour, while its vapour is said to act very strongly on the brain. It can be prepared from guaiacol, also synthetically from salicylic aldehyde, and is used in perfumery, and for flavouring.

COUMARONE ($C_6H_4.CH.O.CH$) is a colourless liquid occurring in that fraction of crude benzol obtained by coal-tar distillation which comes over between 165° and 175° C. It boils at 170° C. and can be isolated as picrate. (See Coumarone Resin and Gums and Resins (Synthetic).)

COUMARONE RESIN (Para-coumarone, Cumaron Resin, Benzo-furane Resin) ($C_6H_4.CH.O.CH$)—A resinous body of varying melting-point, soluble in ether, petroleum, turpentine, acetone, and carbon disulphide, made in the U.S.A. in large quantities. It is gummy to hard in character, and is suitable for replacing ester gums, or even kauri gum, and others in varnishmaking and rubber substitutes. It is made by treatment of the distillate fraction of coal-tar naphtha (between 160° and 200° C.), containing indene and coumarone, with either strong sul-

COUMARONE RESIN (*Continued*)—
phuric acid or aluminium chloride, or by simply heating under pressure and subsequent separation from the polymerizing agent, when it sets to a solid resinlike mass of sp. gr. 1·05 to 1·10. Among other applications it is used for polishing coffee beans. (See T. H. Barry (*Ind. Chem.*, 1927, iii., 431 and 479); I. Burda (*B.C.A.*, 1930, B, 676); Gums and Resins (Synthetic).)

COWRIE—See Gums (Kaurie).

COW-TREE WAX—See Waxes.

CRACKING—Destructive distillation. One type of cracking plant is known as the "Dubb's Unit," and another well-known type of process is that of Cross and Ellis, while a laboratory type of cracking still is depicted in *Ind. Chem.*, 1930, vi., 375.

References: "The Manufacture of Cracked Spirit" (*Ind. Chem.*, 1926, ii., 113); "Cracking of Heavy Oils" (*C.T.J.*, October 17, 1924); "Review of the Scope and Development of Vapour-phase Cracking of Petroleum Hydrocarbons, with special reference to the 'Gyro' Process," by C. R. Wagner (*B.C.A.*, 1929, B, 877); A. N. Sachanen and others on "Cracking Process" (*B.C.A.*, 1929, B, 383); R. H. Griffith on "Valuations and Cracking of Gas Oils" (*J.S.C.I.*, 1929, **48**, 252 T); Morrell and Egloff on "Cracking of Tar Acids from Coal" (*J.S.C.I.*, 1930, **49**, 263 T and 267 T); W. H. Jones on "Cracking of Petroleum Oils and Low-temperature Coal Tars" (*B.C.A.*, 1930, B, 1011); Egloff, Lowry, and Schaad—being a comprehensive review of papers and patents respecting cracking processes (*J. Inst. Petroleum Tech.*, 1930, **16**, 133); Dunstan, Hague, and Wheeler on "Heat-treatment of Hydrocarbons" (*J.S.C.I.*, 1931, **50**, 313 T); also Distillation, Petrol, Petroleum, and Rosin Oil.

CREAM—See Milk.

CREAM OF TARTAR (Potassium bitartrate, $C_4H_5O_6K$)—See Argol, Potassium Bitartrate, and Tartar.

CREATINE ($C_4H_9N_3O_2H_2O$)—A crystalline body contained in the juice of animal muscles (flesh), soluble in hot water, and which combines with hydrochloric acid to form a well-defined compound, $C_4H_9N_3O_2,HCl$. It is accompanied by another substance, named creatinine ($C_4H_7N_3O$)—an invariable constituent of urine. Creatine appears to become changed in the blood into urea and creatinine, as it does also when heated with acids. As to its synthesis, see H. King (*J.C.S.*, 1930, p. 2374).

"CREOCIDE"—A proprietary fluid weed-destroyer and disinfectant, miscible with water, prepared from certain creosotic principles.

CREOSOL ($C_8H_{10}O_2$)—A dihydric phenol. (See Creosote (Beechwood).)

CREOSOTE (**Beechwood**)—A colourless or faintly yellow creosotic liquid obtained from the tar resulting from the distillation of beechwood, and containing, amongst other phenolic constituents, guaiacol and creosol [$C_8H_{10}O_2$ or $CH_3.C_6H_3(OH)(O.CH_3)$]. It is soluble in alcohol and ether, and to some extent in water; sp. gr., 1·080; b.p., 205° to 220° C. It is preferably prepared from *Fagus sylvatica* or *F. ferruginea*. (See Guaiacol.)

CREOSOTE (Coal Tar)—A dark-coloured, thick liquid by-product from coal-tar distillation, generally containing phenols (which can be removed by treatment with caustic soda); used as a wood preservative and for the preparation of disinfectant liquids. With respect to its separation from tar and pitch, see Coal, Coke, and Tar.

CREOSOTE (Wood)—Creosote obtained by the distillation of wood is quite distinct from coal-tar creosote, although both contain certain ingredients in common. When refined it is a colourless, oily liquid of complex composition, containing phenols and cresols, having a pungent, penetrating odour, and it is to its active principles that wood-vinegar, tar-water, soot, and smoke owe their preservative and antiseptic values. It is probably more allied to blast-furnace creosote in chemical nature than to coal-tar creosote. Owing to the decreased demand for anthracene, creosote oil is now often found in admixture with the anthracene oils. (See Creosote (Beechwood), Coal, Motor Fuels, and Wood.)

CREOSOTE CARBONATE (also known under the commercial name of "creosotal")—A clear, colourless, or amber-coloured, viscid liquid consisting of an indefinite mixture, made by conducting a stream of phosgene gas (carbonyl chloride, $COCl_2$) into a solution of creosote in sodium hydrate. The oily liquid thus produced in a separated form is first washed with a weak alkali and then with water. It contains an equivalent of about 90 per cent. creosote, and is employed as an inhalant in pulmonary tuberculosis and as an intestinal antiseptic. Sp. gr., 1·1413 to 1·1696.

"CREPESAC"—Trade name of a new kind of paper sack to carry weights up to 2 cwts.

"CRESINEOL"—A crystalline antiseptic compound of cineol and cresol, m.p. 55·2° C.; soluble in most organic solvents, and decomposable by alkaline hydrates; indicated for use as an intestinal antiseptic and in compounding dusting powder.

CRESOL (C_7H_8O or $CH_3,C_6H_4.OH$), obtained from coal tar and present in the tar from pine and beech wood, is a homologue of phenol (C_6H_6O or C_6H_5OH). There are three isomeric forms—ortho-, meta-, and para-cresol. Orthocresol is a crystalline intermediate which has a sp. gr. of 1·0415 at 25°/4°, b.p. 191° C., and m.p. 30·45° C.; metacresol is a liquid of sp. gr. about 1·03 at 25°/4°, and b.p. 202° C., used in the manufacture of synthetic perfumes; paracresol is a white crystalline intermediate of sp. gr. about 1·03 at 25°/4°, m.p. 36° C., and b.p. 201·8° C.

Crude liquid cresol as obtained from the distillation of tar can be rendered soluble in or miscible with water by the use of resin or oil-soap and alkali, and in this form it constitutes the basis of many disinfectant preparations, sheep dips, and insecticides. Of the cresols (all of which exhibit strong germicidal properties), *metacresol* is the most powerful, and this is used in making synthetic resins and as a photographic developer. Useful application has been made industrially in respect of the capability of cresol for absorbing many vapours by solvent action, as, for example, those of ether-alcohol.

CRESYLIC ACID—Another name for cresol, but often used in respect of indefinite mixtures of cresols and phenol marketed as 97 to 99 per cent. Cresylic acid forms salts with metals of the type sodium cresylate ($CH_2.C_6H_4.ONa$), and large quantities are used in the flotation treatment of ores.

"CREX"—A proprietary laundry detergent, stated to be free of silicate, caustic soda, and bleach.

CRIME (**Detection—Chemical Agencies**)—See C. A. Mitchell (*Analyst,* 1932, **57,** 144) and *Some Persons Unknown,* by H. T. F. Rhodes (John Murray, London).

CRISTOBALITE—See Silica.

CRITH—The weight of a litre of hydrogen at standard temperature (0° C.) and pressure (760 mm.)—viz., 0·0896 gramme.

CRITICAL CONSTANTS—The critical point is that at which two phases continually approximating each other become identical, forming one phase. Thus at a higher temperature the vapour generated from a liquid becomes a gas. The critical temperature of water is 364° C., the critical pressure 195 atm., and the critical density 0·208.

References: The Foundation of Chemical Theory, by R. M. Cavern, pp. 100 and 111 (Blackie and Sons, Ltd., London); annual tables of constants and numerical data (physical, chemical, and technological) published under the patronage of the International Research Council and the International Union of Pure and Applied Chemistry. Particulars of the fifth volume (1917-1922) of these tables can be obtained from Dr. C. Marie, 9, Rue de Bagneux, Paris (6^e), or the Cambridge University Press; a volume of *International Critical Tables of Numerical Data of Physics, Chemistry, and Technology,* published by the McGraw-Hill Book Co., Inc., N.Y. and London. See also Chemical Terms, Colloid Chemistry, Constants (Physico-Chemical), Densities, Gases, and Quantum Theory.

CRITICAL DENSITY—See Densities.

CRITICAL PRESSURE—See Gases.

CRITICAL TEMPERATURES—See Gases.

CRITICAL VOLUME—See Volume (Critical).

CROCIDOLITE—See Asbestos.

CROCOISITE (**Crocoite**)—A native lead chromate (PbO,CrO_3), of crystal system, No. 5, and sp. gr. 6·0. (See Gosner and Mussgnug (*B.C.A.,* 1931, A, 550); Lead and Chromium.)

"CROCUS"—"Crocus of antimony" is the oxysulphide of that metal and "Crocus of Mars" is an old name for finely divided red oxide of iron. (See also Saffron.)

"CRONITE"—A heat-resisting alloy of the nickel-chromium class, the composition being given as approximately 65 per cent. nickel, 16 per cent. chromium, 1 per cent. manganese, 0·75 per cent. silicon, and 16 per cent. iron, withstanding a temperature of 650° to 700° C.

CROOKESITE—A rare mineral containing copper selenide and about 17 per cent. thallium. (See Thallium.)

CROTON OIL is a fatty, yellowish-brown liquid, with a sp. gr. of 0·940 to 0·960, and rancid odour, contained to the extent of about 50 per cent., expressed from the seeds of *Croton tiglium* (N.O., Euphorbiaceæ) between hot plates. It is soluble in alcohol and ether, and contains an oily active principle named crotonol ($C_9H_{14}O_2$), to the presence of which it owes its drastic purgative property and its irritating action on the skin. It also contains a resin, to which the oil owes its optical activity. The plant is a native of India and the more easterly tropical parts of Asia.

CRUCIBLES—Vessels or pots employed for heating solid chemical substances to a high temperature or for melting metals, etc. They are variously made of earthenware, plumbago, porcelain, silica, platinum, iron, silver, and nickel, but the metallic ones may not be employed for melting metals or under circumstances in which another metal may be reduced from the compound in use to its free (uncombined) state, on account of the danger of damaging or ruining the vessel through the production of an alloy by combination of the other metal with the metal of the crucible. Analytical crucibles with an improved form of lid are described by J. D. Main Smith (*J.S.C.I.*, 1925, **44**, 539 T).

Amongst other practical applications of crucibles may be mentioned their employment for incinerating compounds of partly organic nature with the view of burning off the organic constituents. Platinum crucibles are commonly used in chemical laboratories for fusing inorganic substances.

Gooch Crucible—A cup of glazed porcelain, usually about 1½ inches high and of 1¼ inches diameter at the top, tapering somewhat to the bottom, which is pierced with a number of small holes. A layer of asbestos is laid on this by pouring a suspension in water of the finely divided material into the cup, and allowing it to drain; then a perforated porcelain plate is laid on top of the asbestos "mat." The crucible is fitted into the neck of a vacuum flask, in which low pressure is maintained by a filter-pump. This arrangement serves for the filtration of solutions which would pass only very slowly through an ordinary paper filter or would act on it chemically. The crucible with the precipitate can be dried and ignited for weighing.

CRUSHING MACHINERY—See Grinding and Mixers.

CRYOHYDRATES—See Solution, p. 842.

CRYOLITE (Na_3AlF_6)—A mineral double fluoride of sodium and aluminium, of crystal system, No. 5, and sp. gr. 3·0, occurring abundantly on the coast of West Greenland; used as a flux and in enamelling; also in the glass industry and for glazing pottery. (See Aluminium and Fluorine.)

CRYOSCOPY—A freezing-point method of determining molecular weights by determining the depression which takes place upon dissolving a known quantity of the substance in a solvent according to the formula

CRYOSCOPY (*Continued*)—

M.W. $= C\frac{p}{t}$ where M.W. = molecular weight, C = a constant characteristic of the solvent, p = representing grammes of substance dissolved in 100 grammes solvent, and t = the depression in degrees C. The so-named "Hortvet" cryoscope is a device for testing milk and other liquids, and a new type of thermometer for the cryoscopy of aqueous solutions is described by H. Menzel (*B.C.A.*, 1927, A, 335). (See R. Wright (*J.C.S.*, 1925, cxxvii., 2334) and Freezing-Points.)

CRYSTALLOIDS—See Crystals.

CRYSTALS—Substances of definite symmetrical or geometrical form—the reverse of the amorphous state. If some common alum be dissolved in cold water until it will dissolve no more, or, in other words, until the solution is saturated at the observed temperature, and then transferred to an evaporating dish and more alum dissolved by the aid of heat until again the solution is saturated at this higher temperature, it will, upon cooling, deposit a mass of crystallized alum—viz., that further quantity which was dissolved by the aid of applied heat.

Some liquids exhibit a suspension of crystallization or solidification—for example, glycerine may be cooled to $-30°$ C. without solidifying, but upon the addition of a crystal of the solid substance, the whole quantity freezes at once, and will not melt again until a temperature of 15·5° C. is reached.

Crystallization is often resorted to as a means of purifying a particular constituent of a solution from accompanying and less crystalline substances or bodies devoid of crystalline form, although it has been established as a fact that practically all crystals contain inclusions of mother-liquor extremely difficult to remove. Disturbed crystallization is used when great purity is desired, as the smaller the crystals the greater the purity.

Many chemical salts have the property of combining with water in assuming the crystalline form from a state of solution; thus cupric sulphate, which has the formula $CuSO_4$ in its anhydrous form, crystallizes from water in chemical combination with 5 molecules of water ($CuSO_4,5H_2O$), magnesium sulphate with 7 molecules ($MgSO_4,7H_2O$), and so on, and water so combined is termed "water of crystallization." In some cases crystals lose water *in vacuo*, and the water of crystallization is generally expelled from salts by heating to 100° C. An equipment for the conduct of continuous crystallization is described by H. Seymour (*Ind. Chem.*, 1925, i., 307). (See Efflorescence.)

Pope has defined a crystal as an arrangement of matter in which every point is repeated with a similar environment throughout the structure, and has directed attention to the fact that certain doubly-refracting liquids retain some element of the homogeneity of crystal structure possessed by the crystalline solids from which they are produced, as, for example, ethyl *p*-azobenzoate. (See also Bradfield and Jones (*J.C.S.*, 1929, p. 2660); report of P. Debye's lecture on "Scattering of X-rays in Gases and its relation to Molecular Structure" (*Chem. and*

CRYSTALS (*Continued*)—

Ind., 1930, **49**, 326); and G. Natta on "The Crystalline Structure of Hydrogen Sulphide and Hydrogen Selenide" (*B.C.A.*, 1930, A, 1350).

To use the words of U. R. Evans, "the essential character of a crystal is an *ordered* internal arrangement of the component atoms on a definite lattice," and all modern studies of the crystal nature start from this idea. (See his article on the external forms of crystals referred to later on.)

Crystals may be classified as follows:

(1) The cubic isometric or regular system, comprising five crystal classes, including, for example, rock salt, alum, and the diamond.

(2) The quadratic or tetragonal system, comprising seven classes, of which potassium dihydrogen phosphate, potassium ferrocyanide, and tinstone are examples.

(3) The hexagonal system comprises five sub-divisions, and in these quartz and lead iodide are included.

(4) The rhombohedral or trigonal system, comprising seven subdivisions, including calc spar, olivenite, mispickel, and celestine.

(5) The rhombic or orthorhombic or prismatic system, comprising three groups, as exemplified by magnesium sulphate, potassium sulphate, and nitre.

(6) The monoclinic or monosymmetric system, comprising three subdivisions, including gypsum, borax, and soda crystals.

(7) The triclinic, asymmetric, or anorthic system, comprising two divisions, of which copper sulphate and potassium dichromate are illustrative.

Many chemical bodies assume the crystalline state when they change from the liquid or gaseous condition into the solid form; others upon cooling of fused masses such as sulphur and antimony, or upon sublimation, as, *e.g.*, iodine, phosphorus, and arsenious oxide.

The diamond and many other precious stones probably result from processes of fusion effected under great pressure, and a very large number of definite chemical bodies are found in nature in a crystalline condition.

Crystalline bodies are really the simplest kind of solids, the molecules being locked together in regular structure.

It has been stated as a statistical truth that everything strives towards symmetry in so far as the environment will allow; and it has been proved that charcoal is really crystalline, and that the so-called colloidal particles of silver and gold are in reality ultra-microscopical crystals; indeed, it is alleged that all true solids are crystals. (See P. P. Von Weimann and T. Hagiwara (*B.C.A.*, 1927, A, 410).)

Definitely crystalline bodies exhibit a peculiar susceptibility to cleavage—that is, being split in some directions more readily than in others, and of allowing heat and light rays to pass more readily in certain directions as compared with others, thus giving rise to the phenomena of double refraction. Physicists regard the spectra furnished by crystals, when subjected to X rays, as furnishing information concerning the arrangement of the atoms in many of the simpler crystalline forms, and the number of molecules associated with the crystal unit cell. It depends

CRYSTALS (*Continued*)—

upon the measurements of the angles of incidence of X rays which show maxima and minima of interference in the reflected rays. According to W. H. Bragg and his son, W. L. Bragg, the atoms in a crystal are independent of each other, being arranged in a regular order at measurable distances between. (See Bragg's book referred to below.) In certain cases, such as that of potassium chloride, every atom occupies a symmetrical position in the crystal structure, each potassium atom being symmetrically surrounded by six chlorine atoms, and each chlorine atom by six potassium atoms in a space lattice.

In the diamond, every carbon atom is symmetrically surrounded by four other carbon atoms, arranged at the corners of a tetrahedron in such manner that the whole crystal is one continuous molecule, thus explaining, as is thought, its great density and hardness.

It would also appear that the internal molecular structure of crystals is such that the maximum electrostatic stability is attained. The subject is too complicated to be further explained in a work of this character, but its continued study is likely to throw considerable light upon atomic structures and their connection with electrons.

With respect to the present state of knowledge concerning the magnetic properties of crystals, it is known that their diamagnetic susceptibilities vary with direction in the crystals, and it has been ascertained that the variations are related to the arrangement of their ionic or molecular group in the lattices.

Little or nothing is yet known of the determining *causes* of the formation of crystals or why various substances assume varying crystalline forms. Alum, for instance, sometimes crystallizes in cubes and at other times in octahedra, and similarly common salt, which ordinarily crystallizes in cubes, assumes the octahedral form when a small quantity of urea is present in the solution.

According to U. R. Evans, the same spatial arrangement may result in the production of cubes or octahedra, plane or curved surfaces, symmetrical or amorphous bodies; all, however, of the essential character of crystals. (See *Chem. and Ind.*, 1925, **44,** 791 and 812.)

The size of crystals is alleged to be dependent on the molecular concentration and on the degree of supersaturation taken in conjunction therewith. As a rule they are of larger size when solutions of salts are not too concentrated and are allowed to cool slowly. If the conditions of supersaturation are carefully observed, agitation or motion exercises no effect on crystal growth. In manufacturing crystallization operations, among other difficulties encountered is that of latent heat, which is generally of the order of 100 B.Th.U. per lb. of crystals produced.

Substances capable of assuming crystalline form are classified as *crystalloids* to distinguish them from *colloids*—that is, substances which cannot be definitely crystallized—and from the larger class of so-called *amorphous* substance.

Isomorphous substances are those which crystallize in the same form, such as the sulphates of zinc and magnesium, whereas when a

CRYSTALS (*Continued*)—

substance (such as sulphur) is capable of crystallizing in two forms it is termed *dimorphous.*

Isomorphous analogous chemical substances can replace each other wholly or partially in many crystalline compounds without alteration of the crystalline form.

The view is generally held that when two substances have forms identical in crystallographic system, the molecules contain an identical number of atoms similarly united. (See Hugh Griffiths on "Mechanical Crystallization" (*J.S.C.I.*, 1925, **44,** 7 T; *C.T.J.*, 1924, **75,** 486, and 1925, **76,** 67); C. H. Desch on the growth of crystals (*C.T.J.*, 1926, **78,** 350 and 411); T. K. Barker on the "Development and Formation of Crystals" (*J.S.C.I.*, 1925, **44,** 20 T); "Crystal Structure and Chemical Constitution" (a general discussion, Faraday Society, 1929); "Theory of Recrystallization," by G. Tamman (*B.C.A.*, 1930, A, 140); "The Study of Crystals, with Special Reference to Chemistry," by A. Stuart (*Chem. and Ind.*, 1930, **49,** 989); "Crystallization Technology," by W. E. Gibbs, reported in the *C.T.J.*, 1930, **86,** 226 and 258); *Chem. Soc. Annual Report,* 1929, **26,** 277; *An Introduction to Crystal Analysis,* by W. Bragg (G. Bell and Sons, Ltd., Lond.); *The Structure of Crystals,* by Wyckoff (The Chemical Catalog. Co., Inc., N.Y.); *X Rays and Crystal Structure,* by W. H. and W. L. Bragg (G. Bell, London); Amorphous, Atoms, Colloid Chemistry, Dialysis, Electrons, and Radio-activity.)

CUBA WOOD—See Fustic.

CUBEBS, OIL OF—The volatile oil obtained from the unripe fruit of *Piper cubeba* L., a native of Java, and cultivated also in Sumatra and Borneo. It is obtained by distillation with water, is of pale green colour or colourless, thick, aromatic odour, soluble in alcohol and ether, contains cubeb camphor, dipentene, *l*-pinene, camphene, and cadinene, and finds some application in medicine as a diuretic. The yield is from 10 to 18 per cent.; sp. gr., 0·905 to 0·92 at 15° C.; ref. ind., 1·485 to 1·496 at 25° C.; and rotation, $-25°$ to $-40°$ at 20° C.

CUBIC CENTIMETRE (c.c.)—It having been ascertained that 1,000 c.c., measured on the assumption that 1 c.c. of water weighs 1 gramme, are really equal in volume to 1·002 litres, a new unit has been arrived at by the Joint Committee for the Standardization of Scientific Glassware. (See Weights and Measures.)

CUCUMBER OIL (Gourd Oil)—A greenish-yellow drying oil expressed from cucumber and pumpkin seeds (genus, Cucurbitaceæ), soluble in alcohol, ether, etc.; sp. gr. 0·923, sap. v. 188·7, and i.v. 121; used as fuel, for illuminating, and in medicine.

CUDBEAR—See Archil.

CUICUS BENEDICTUS OIL—From the seeds of *Cuicus benedictus;* sp. gr. at 15° C. 0·9255, sap. v. 196·5, acid. v. 16·6, i.v. 139·6. It is a semi-drying oil similar to hemp oil, and suitable for making soap and varnish.

CULLET—See Glass.

CULM—Coal dust—especially that of anthracite.

"CUMALINE"—An American rubber solution recommended for addition (3 to 6 per cent.) to pure oil paints for improving the flow and appearance, and increasing the elasticity and resistance to weather influences.

CUMARON RESIN—See Coumarone Resin and Gums and Resins.

CUMENE (C_9H_{12} or $C_6H_5.CH(CH_3)_2$)—A liquid homologue of benzene, of sp. gr. 0·866, and b.p. 153° C., existing ready formed in Burmese naphtha, and produced by the distillation of cumic acid ($C_{10}H_{12}O_2$), with lime or baryta. It is soluble in alcohol and ether, yields benzoic acid on oxidation, and is used for sterilizing catgut.

CUMIN ALDEHYDE—See Perfumery.

CUMIN (Cummin) OIL—From the fruit of Roman caraway (*Cuminum cyminum*), a genus of Umbelliferæ, common in Egypt and cultivated in Syria, Morocco, East Indies, etc.; sp. gr. 0·91 to 0·93 at 15° C., ref. ind. 1·497 to 1·509 at 20° C., rotation +4° to +8° at 20° C., and containing 20 to 30 per cent. cumic aldehyde with some cumene and pinene; yield is from 2·5 to 4 per cent.

CUPELLATION—An operation conducted in a *cupel* (*cupola*)—that is, a shallow, oval-shaped bone-earth or other dish which is heated in a reverberatory furnace in course of assaying, testing, or refining metals. (See Silver.)

CUPFERRON ($C_6H_5(N.NO)O.NH_4$)—The ammonium salt of nitrosophenyl-hydroxylamine. It is a colourless crystalline body soluble in water, used in the practice of quantitative analysis for the determination of uranium; also for separating copper and iron from other associated metals (they alone being precipitated by cupferron from strongly acid solutions). The precipitate is washed on a filter first with water and then with ammonium hydrate, which dissolves the copper but not the ferric compound, which is soluble in chloroform, ether, and acetone, and may thus be obtained free from other associated metallic salts.

The ferric compound can be converted into oxide by ignition and weighed as such.

The use of this reagent is limited by reason of its explosive character.

CUPRADOR—A corrosion-resisting, copper-bearing steel.

CUPRAMMONIUM SILK—See Silk Substitutes.

"CUPREN"—The name given to certain acetylene polymerization products containing only 0·2 to 0·3 per cent. copper, obtained by the action of copper oxide on acetylene at about 230° to 260° C. They are high-molecular, quite insoluble bodies, used in compounding certain explosives, stated to be superior to dynamite; for example, eleven parts by weight of nitroglycerin mixed with one part by weight of the polymerized acetylene.

"Cupren" is also stated to be useful in compounding liquid oxygen explosives.

CUPRITE—See Copper.

CURARA (Curari)—A resinous body extracted from plants of the genus *strychnos,* and used by the Indians of South America for poisoning their arrows. The active principle is a yellow substance named curarine ($C_{19}H_{26}N_2O$), soluble in water and alcohol. The light-coloured curara comes from districts to the south of the equator, and the dark one from north equatorial areas. (See Späth (with others), *B.C.A.*, 1928, A, 1264.)

CURCAS OIL—Yielded to extent of from 32 to 33 per cent. from the seeds of *Jatropha curcus* (Linn.), or "physic nut" of the East Indies. It exhibits purgative, emetic, and drying properties; sp. gr. 15°/15° C. 0·9191, sap. v. 191·6, and i.v. 98·7. The plant which is commonly found as a hedge growth in Siam is of similar character.

CURCUMENES—Terpene bodies contained in the essential oil occurring in the rhizomes of *Curcuma aromatica*, Salise. (See Rao and Simonsen, *J.C.S.*, 1928, p. 2496.)

CURCUMIN—See Turmeric.

CURITE—A radio-active crystalline mineral found at Kasolo (Belgian Congo), giving upon analysis the composition $PbO_5,UO_3,4H_2O$.

CUSCUS OIL—See Vetiver Oil.

CUTCH—See Catechu and Tannins.

CUTTING FLUIDS are really lubricating agents, one function of which is to keep the working parts cool, and, apart from its rusting action, water is a suitable agent. To avoid rusting, soda or soap are often used in association, whilst lard oil is recognized as nearly indispensable in certain cutting operations, and certainly superior to mineral oils, having a much higher adhesion for metal.

Other oils, such as sperm, castor, and rape, partake of the advantages exhibited by lard oil, and triethanolamine is advocated as a base for cutting oils in the form of the oleate soap. (See *C.T.J.*, 1928, **83,** 165, and 1929, **85,** 55.)

Emulsions of various animal, vegetable, fish, and mineral oils are often employed, and are said to be suitable for drilling, reaming, milling, planing, and sawing. For tapping and threading, lard oil and others resembling it are recommended, but the character of the operation and the nature of the metal determine the choice of the cutting liquid. (See Lubricants.)

CUTTLE-FISH—A molluscous animal of the order *Cephalopoda* and genus *sepia,* possessing a so-called "ink bag"—a gland near the liver—from which it discharges, when pursued, a dark-coloured liquid which discolours the water and obscures its passage. It is from this material that the *sepia* of painters is prepared, by dissolving it in potassium or sodium hydroxide, reprecipitation with hydrochloric or sulphuric acid, washing and drying. Sepia is dark brown in colour, of fine grain, and is stated to consist of a mixture of calcium and magnesium carbonates, melanin, and an organic colouring matter. Cuttle-fish bone is composed of calcium carbonate 89·30 per cent., insoluble mineral matter 0·23 per cent., organic matter 9·44 per cent. containing 0·72 per cent.

CUTTLE-FISH (*Continued*)—

nitrogen, iron oxide and alumina 0·33 per cent., phosphoric acid traces, and undetermined matter 0·70 per cent. It makes a good poultry grit and liming material for soils, and is also used in making tooth powder and polishing powders.

The cuttle fish, allied to *Elodone moschata*, is said to contain the odorous principle of ambergris, and these cephalopods are consumed by the sperm whale. (See Ambergris.)

CYANAMIDE (CN_2H_2), when pure, is a colourless, crystalline body, prepared from cyanogen chloride and an ethereal solution of ammonia. It is deliquescent, melts at 40° C., is soluble in water, alcohol, and ether, and behaves chemically both as a weak base (forming crystalline salts with acids) and as a weak acid (yielding sodium, lead, silver, and calcium compounds). It exhibits some toxic action, persons working with it being liable to fleeting exanthemata of the head and chest, etc. The calcium derivative is commercially produced by heating calcium carbide in the presence of a little calcium chloride to about 1,000° C. in a current of air or nitrogen, the heat being produced by an electric current passing through carbon resistances placed in the powdered carbide—

$$CaC_2 + N_2 = CaCN_2 + C + 74{,}990 \text{ calories,}$$

or by passing nitrogen (obtained from liquefied air) over a mixture of lime and carbon electrically heated to 2,000° C., an excess of carbon being used. The crude product is a black powder containing 58 to 60 per cent. of calcium cyanamide, and is used as a fertilizing agent under the name of "nitro-lime," the nitrogen content being transformed by chemical changes into ammonia when the substance comes into contact with water. It does not suffer loss of nitrogen on storage. The other constituents of nitro-lime are about 20 to 22 per cent. of free lime, 8 to 9 per cent. of silica, alumina, and iron, and 11 to 12 per cent. of carbon in the form of graphite. Calcium cyanamide does not, it is stated, appeal to farmers very much as a fertilizer, and possibly this is because under certain soil conditions it polymerizes to calcium dicyanodiamide. In any case, it has to undergo changes which result in the production of ammonia for it to become effective. As a result of field trials, E. J. Russell has shown that in comparison with nitric nitrogen with an effectiveness of 100, ammoniacal nitrogen shows 97 and cyanamide 90 or less. The world's production was estimated in 1922 as about 900,000 tons.

When it is desired to utilize cyanamide to produce ammonia, it is ground up fine, after first of all being damped to get rid of any unchanged carbide, and then heated in an autoclave with superheated steam at 150 pounds pressure, when the change represented as follows occurs:

$$CaCN_2 + 3H_2O = CaCO_3 + 2NH_3;$$

the ammonia thus liberated is turned to account as described under the heading of Nitrogen.

An improved process, used by the British Cyanide Company, con-

CYANAMIDE (*Continued*)—

sists in passing nitrogen over a mixture of barium carbonate and carbon at high temperatures, when barium cyanide is formed, a carbide being first of all produced; this takes up nitrogen and yields a mixture of cyanide and cyanamide, which last-named compound, combining with a further amount of carbon, forms cyanide. (See W. S. Landis (*C.T.J.*, 1927, **80**, 407); and Wæser's *The Atmospheric Nitrogen Industry*, vol. ii. (J. and A. Churchill, London).)

CYANAMIDE HYDROCHLORIDE ($CN_2H_2.2HCl$) is a colourless crystalline salt of fairly stable character, which decomposes readily at 100° C., and is far less hygroscopic than cyanamide. Its uses and production are dealt with in the *C.T.J.*, 1926, **78**, 725.

CYANIC ACID—See Cyanogen Compounds.

CYANIDATION—See Ores.

CYANIDES—See Hydrocyanic Acid, Cyanamide, and Cyanogen.

CYANITE (**Kyanite**)—A mineral allied to *andalusite* and *sillimanite* ($Al_2O_3.SiO_2$), but of different crystalline forms, occurring in varying colours—red, yellow, and blue. The Indian variety is stated to be entirely converted into *mullite* crystals and a silicious glass upon firing to 1,450° C. (See Sillimanite.)

CYANOGEN AND ITS COMPOUNDS—

Cyanogen (C_2N_2) is a very poisonous, colourless gas, soluble in water and alcohol, having an odour something like that of bitter almonds, and which behaves in many respects as a halogen, the group CN playing the part of a radical.

It is obtained by heating mercuric cyanide and collecting it over mercury (as it is soluble in water), and can be condensed to a colourless liquid of sp. gr. 1·8. According to B. Ricca (*B.C.A.*, 1926, A, 489), the gas can be best collected over a saturated solution of sodium sulphate or chloride acidulated with 10 c.c. hydrochloric acid per litre, the gas being practically insoluble in that medium. It is inflammable, and when burned is resolved into carbon dioxide and nitrogen. In combination with hydrogen it forms hydrocyanic acid (HCN).

Carbon and nitrogen do not combine directly, but heated together with an alkali such as potassium carbonate, or by heating a mixture of potassium carbonate and carbon in a stream of ammonia gas, potassium cyanide (KCN) is formed. It is also made by the fusion of calcium cyanamide with potassium hydroxide.

Sodium cyanide can be prepared by heating sodamide with charcoal, sodium cyanamide being thus produced, and subsequently resolved into the cyanide.

The process based upon the equation

$$Na_2CO_3 + 4C + N_2 = 2NaCN + 3CO$$

consists in heating a mixture of sodium carbonate and carbon in a stream of nitrogen or producer-gas under a pressure of 15 lbs. to the sq. inch in the presence of a suitable catalyst such as ferric oxide in

CYANOGEN COMPOUNDS (*Continued*)—

admixture with an alkaline halide (sodium fluoride), the product being subsequently leached and otherwise dealt with so as to yield sodium cyanide of 96 and 98 per cent. purity. Incidentally, the residual carbon is said to be useful for decolourizing and as a pigment. (For details of this process developed by the Du Pont Company of Wilmington, U.S.A., see *C.T.J.*, 1925, **76**, 40.) The nitrogen fixation is stated by E. W. Guernsey and M. S. Sherman to occur in three stages, the first being the reduction of the sodium carbonate to the metal sodium, then the formation of sodium carbide from its elemental constituents, and lastly the absorption of nitrogen by gaseous sodium carbide to form sodium cyanide. (See *J.Amer.C.S.*, July, 1925, and Sodium (Cyanide).)

Sodium cyanide can also be produced in good yield by heating at 1,000° C. in an electric furnace a mixture of sodium sulphate, barium carbonate, and carbon, using iron powder as a catalyst, in a slow stream of nitrogen (R. Hara and H. Miura, *J.C.S. Abs.*, June, 1925, I., 645).

A mixture of alkaline cyanides is produced when potassium ferrocyanide is fused with metallic sodium, the reaction being as follows:

$$2(K_4Fe(CN)_6) + Na_4 = 8K(CN) + 4Na(CN) + Fe_2.$$

The fused fluid mass of cyanides can be poured off from the metallic iron, and forms a snow-white mass upon cooling.

A new process for the manufacture of sodium cyanide is in course of development in Germany, dependent upon the action of a mixture of carbon monoxide and ammonia on fused sodium carbonate to which a proportion of cyanide is added originally. Ammonium carbonate and water are separated from the resulting gaseous effluent, which is introduced a second time with the fused subject material.

The cyanides of the alkali and alkali-earth metals are all soluble in water, but those of the heavy metals, excepting mercury cyanide, are insoluble in water. The potassium and sodium cyanides are largely used in the extraction of gold and silver from their ores, also in electroplating and other industries. (See Potassium Cyanide, p. 727.)

Cyanogen Chloride ($CNCl$) is a colourless poisonous liquid of boiling-point 13° C., soluble in alcohol, and used in making poison gases.

Cyanogen compounds are made on an extensive scale from nitrogenous organic matters, such as the clippings of hoofs and hides; thus, when heated with iron and potash, potassium ferrocyanide is produced.

Cyanic Acid ($HCNO$) is a volatile mobile liquid of pungent odour like that of strong acetic acid, and unstable nature, changing with explosive violence into the polymeric bodies, cyanuric acid $(HCNO)_3$ and cyamelide $(HCNO)_x$, when removed from a freezing mixture. By combination with bases it forms cyanates, including ammonium cyanate, which gradually undergoes change at ordinary temperatures, and at 100° C. is quickly resolved into urea, as expressed by the following formula—

$$CNO(NH_4) = CO(NH_2)_2.$$

This is a striking instance of isomeric change by atomic reconstruction brought about by a physical cause. (See Isomerism.)

CYANOGEN COMPOUNDS (*Continued*)—

Potassium cyanate (KCNO) is a white crystalline salt readily soluble in water and alcohol. (See Nitriles.)

Hydrocyanic Acid—See that heading.

Hydro-ferricyanic Acid ($H_3FeC_6N_6$) crystallizes in brown needles, but is readily decomposable, while hydro-ferrocyanic acid ($H_4FeC_6N_6$) crystallizes in the form of white needles, and both of them combine with a number of organic bases forming salts.

Ferricyanides are compound cyanides produced from ferrocyanides by the action of oxidizing agents—for example, potassium ferrocyanide ($K_4Fe(CN)_6$) becomes converted into $K_3Fe(CN)_6$ (potassium ferricyanide).

Ferrocyanides are compound cyanides of iron and other metals, of which potassium ferrocyanide is typical. They are produced from ferricyanides by the action of reducing agents, potassium ferricyanide, for example, yielding the ferrocyanide by the action of grape sugar in presence of potassium hydrate. A process of manufacturing sodium ferrocyanide, which has been carried out in Canada successfully, consists in first of all making sodium cyanide by fluxing a mixture of crude calcium cyanide, rock salt, and calcium carbide in an electric furnace and boiling the solution of the product with a ferrous salt, thus yielding a quantitative amount of sodium ferrocyanide. (See paper on "Cyanogen Compounds" (*C.T.J.*, 1931, **89**, 243); Carbonyl Ferrocyanides, Potassium Compounds (Prussiates) and Prussian Blue.)

CYCLIC—A term applied to compounds containing a ring of atoms in the nucleus. Carbocyclic (homocyclic) compounds are those in which the ring or closed chain is composed entirely of carbon atoms, such as the naphthenes and the benzene derivatives, including naphthalene and anthracene. (See Chains.)

"CYCLOHEXANE"—Described as fully hydrogenated benzene, is a liquid of b.p. 81° C.; m.p. 3° to 5° C.; density 0·778. It distils without decomposition and is a good solvent for waxes and rubber.

"CYCLOHEXANOL"—See Hexalin, Hydrogenated Phenols, and Sextate.

"CYLLIN"—A proprietary coal-tar disinfectant fluid prepared from phenoloids (including xylenols), emulsifying with water.

CYMBOPOGON OIL—Distilled from *Cymbopogon clandestinus*, etc., in Burma; sp. gr. at 15°/15° C. 0·9319 to 0·9734, soluble in 70 per cent. alcohol at 15° C.; it is of pleasant odour, resembles ginger-grass oil, and contains carvone.

CYMENE (**Cymol**) ($C_{10}H_{14}$ or $CH_3.C_6H_4.CH(CH_3)_2$), a benzene hydrocarbon, found in the volatile "cummin oil" obtained from *Cuminum cyminum*, also in water-hemlock seeds and in oil of thyme. It is produced as a by-product in preparing cellulose by the bisulphite process.

CYMENE (*Continued*)—

It is nearly related to camphor ($C_{10}H_{16}O$) (from which it can be readily obtained by a process of dehydration) and to the terpenes ($C_{10}H_{16}$), from which it can also be prepared. It boils at 175° C., has a sp. gr. of 0·856, is soluble in alcohol and ether, colourless, and has an agreeable camphoraceous and lemon-like odour. There are many isomeric cymenes, and it is stated that eighteen varieties have actually been prepared. Para-cymene is used in the synthetic making of menthol and thymol. (See J. W. Schindelmeiser, *Ind. Chem.*, 1926, ii., 497.)

CYSTINE—An amino-acid (di-β-thio-a-amino-propionic acid ($S_2 2(CH_2.CH(NH_2).COOH)$) found in the bodies of plants and animals and among the hydrolytic products of albumins containing sulphur, such as casein, and notable as a constituent of wool.

CYTASE—One of the enzymes in germinating barley which attacks and destroys the cell walls, thus exposing the starch content to the action of the diastase.

DACRYDIUM BIFORME OIL—See Goudie (*J.S.C.I.*, 1923, **42**, 357 T); P. W. Aitken (*J.S.C.I.*, 1928, **47**, 223 T); and W. J. Blackie (*J.S.C.I.*, 1930, **49**, 26 T).

DAIRY CHEMISTRY—See P. Arup on " Vegetable Parchments used as Packing Material " (*Analyst*, 1931, **56**, 149) and Milk.

DAKIN'S SOLUTION—An antiseptic liquid, 10 litres of which can be prepared by the following approved formula: chloride of lime, say 156 grms.; anhydrous sodium carbonate, 78 grms.; anhydrous sodium bicarbonate, 65 grms. The chlorinated lime is first digested with 5 litres of water and subsequently filtered, and the other ingredients are then dissolved in water, and the solution mixed with that of the chloride of lime and made up to 10 litres. (See Eau de Javelle.)

DAMIANA—The dried leaves of *Turnera diffusa* (South-west Texas and Mexico), containing an oil of volatile nature and odour like chamomile.

DAMMAR (Black)—See Gums and Resins.

DAMMARA RESIN (Dammar Gum)—See Gums and Resins.

DANAITE—A cobaltiferous *mispickel.*

DANDELION—See Taraxacum.

DANGEROUS CHEMICALS—As to their safe packing, storage, usage, and transport, see H. J. Phillips, *Ind. Chem.*, 1926, ii., 127, 173, and 197; *C.T.J.*, 1926, **79**, 252; 1927, **80**, 376; and *Chem. Age*, xv., 201.

DANIUM—The name given to what has been described as a newly discovered element (No. 71) in coal.

DANYSZ EFFECT—The better effect realized by treating diphtheria toxin with its anti-toxin by adding it little by little with intervals, thus minimizing the quantity required for reduction of toxicity.

" DARCO "—A variety of decolorizing carbon made from lignite.

DATA SHEETS (respecting Chemical Plant)—A series of these will be found in the *C.T.J.*, as below:

Sheet No.	Subject.	Vol.	Page.	Date.
1.	(Series No. 1) Jacketed pans : Inner pan details	75	489	24/10/24
2.	,, ,, ,, ,, Jacket details	,,	589	14/11/24
3.	,, ,, ,, ,, Cover details	,,	645	28/11/24
4.	,, ,, ,, ,, Vapour pipe details	,,	703	12/12/24
5.	,, ,, ,, ,, Manway cover	76	7	2/ 1/25
6.	,, ,, ,, ,, Leg details	,,	73	16/ 1/25
7.	,, ,, ,, ,, Run-off details	,,	137	30/ 1/25
8.	,, ,, ,, ,, Sight glass	,,	201	13/ 2/25
9.	,, ,, ,, ,, Proportions	,,	265	27/ 2/25
10.	,, ,, ,, ,, Flange details	,,	327	13/ 3/25
11.	,, ,, ,, ,, Flange details	,,	393	27/ 3/25
12.	,, ,, ,, ,, Bolt strengths	,,	456	10/ 4/25
13.	(Series No. 2) Acid eggs : Vertical type	,,	457	10/ 4/25
14.	,, ,, ,, ,, Bottleneck type	,,	515	24/ 4/25
15.	,, ,, ,, ,, Steel type	,,	577	8/ 5/25
16.	,, ,, ,, ,, Standard horizontal type	,,	669	29/ 5/25
17.	,, ,, ,, ,, Two-piece type	,,	790	26/ 6/25
18.	,, ,, ,, ,, Two-piece type	77	38	10/ 7/25
19.	,, ,, ,, ,, Lead-lined cast iron	,,	126	31/ 7/25
20.	,, ,, ,, ,, Splash box (lead)	,,	210	21/ 8/25
21.	,, ,, ,, ,, Cast-iron splash box	,,	272	4/ 9/25
22.	,, ,, ,, ,, Cast-iron hood for inlet	,,	415	9/10/25
23.	,, ,, ,, ,, Lead hood for lead-lined open-top acid cisterns	78	17	1/ 1/26
24.	(Series No. 3)* Autoclaves : Jacket C.1	,,	319	12/ 3/26
25.	,, ,, Steam jackets for	—	469	16/ 4/26

* See "Notes on the Data Sheets concerning Autoclave Design and Construction," by J. Nixon Brewsher (*C.T.J.*, 1926, **78**, 437), and Nomograms.

DATURIN—See Atropine.

DEACON'S CHLORINE PROCESS—See Chlorine, p. 184.

DEAD OIL—The "heavy oil" obtained from the distillation of coal tar.

DEAD-SEA SALTS—The average percentage of salts in the strong brine is given as about 25 per cent., of which 14 per cent. is sodium chloride, 4 to 7 per cent. potassium chloride, and up to 1 per cent. or more magnesium bromide. These salts and carnallite can be extracted by a staged system of evaporation and crystallization. (See *The Times*, August 15, 1927.)

DEARSENICATOR—The "Trepex" dearsenicator is a superior apparatus to the old-fashioned lead tower for bringing sulphuric acid and hydrogen sulphide (as supplied by a suitable generator) into contact for dearsenication, the gas entering at the acid outlet end and being counter-current to flow of the acid. The complete unit also comprises filters for arresting the precipitated arsenic sulphide. The actual dearsenicator for dealing with sulphuric acid is made of cast iron, while for dealing with other acids which attack cast iron the apparatus is made of lead, timber, or ebonite. It is also applicable for gas-washing, and as a substitute for the Gay-Lussac tower in the "chamber" sulphuric acid process, etc.

"DECALIN"—See Dekalin.

DECANTATION—Pouring off liquid from a deposited sediment or precipitate; also used for partial separation of immiscible liquids.

DECOCTION—An infusion or extract prepared by subjecting a crude material to the action of a solvent for the purpose of extracting its soluble constituents, using heat if required.

DECOLORIZERS—See Bentonite, Bleaching, Carbon, "Floridin," Fuller's Earth, Hydrogen Dioxide, Kieselgühr, and Ozone.

DECOMPOSITION—When a chemical compound is broken up into its constituent parts by chemical or physical means, it is said to be decomposed, the decomposition being effected by the exercise of a greater force than that of the original binding chemical affinity.

There are many ways or methods for effecting the decomposition of chemical compounds. Some can be readily decomposed by heating; in others an electric current passed into them in a molten state or into their solutions will effect the purpose; whilst in yet other cases mere exposure to light suffices, many of the silver compounds, for example, suffering chemical change in this way, and practical advantage of this fact is taken in the art of photography.

Acidulated water can be decomposed or broken up into hydrogen and oxygen by passing a current of electricity through it.

Limestone is a chemical combination of lime and carbon dioxide, which, when strongly heated—in lime-kilns, for example—is decomposed into the two parts. (See Chemical Interactions, Dissociation, and Eremacausis.)

DECORTICATION—Shelling of seeds, previous to crushing in order to extract the oil contained in them by pressure or the action of solvents.

DECREPITATION—Physical rending or flying apart of the joints of the crystalline structure of certain minerals and salts when heated, attended with a crackling noise. Common salt, lead nitrate, and calcspar exhibit this behaviour. Decrepitation of barytes is attributed, in common with that of water-soluble salts, such as lead nitrate, to the content of included water; celestine (strontium nitrate) and lead chromate also decrepitate upon heating when they contain a small quantity of water.

DEFECATION—Processes of purification or freeing from dregs. (See Sugar.)

DEFLAGRATION—Rapid combustion with evolution of light and heat, as when a strip of magnesium foil or thin iron wire is burned in oxygen gas. A mixture of nitre with antimonious sulphide, thrown into a red-hot crucible, burns with deflagration, the sulphur being oxidized by the oxygen of the nitre.

DEGRAS—A crude grease obtained from sheep's wool and the tannage of chamois leathers; used in soap-making and as a leather dressing. It can also be made from fish oils, etc. (See Adeps Lanæ and Wool.)

DEGREASING of Metals, etc.—Apart from heating followed by wiping and the use of solvents such as petrol, carbon tetrachloride, benzine,

DEGREASING (*Continued*)—

etc., or chemical cleaners such as caustic soda or sodium carbonate and scrubbing, an emulsion degreasing agent named "P_3" has been recently marketed from Germany, consisting of a powder mixture of water glass and tri-sodium phosphate. It can be used alone or with caustic soda or potash liquor. (See *C.T.J.*, 1931, **88**, 15, taken from *Engineering*.)

DEHYDRATION—The elimination of water. The water of crystallization contained in many salts is eliminated by heat; again, when alcohols are heated to from 400° to 500° in presence of alumina, they are decomposed into olefines and water and so forth. Hackspill and Kieffer have investigated the dehydration of many metallic oxides and salts (*B.C.A.*, 1930, A, 1535). (See Desiccator and Drying.)

DEHYDROGENATION—The removal of hydrogen from compounds by chemical means. (See Aldehydes.)

DE-INKING—See Paper.

"DEKALIN" (Decahydronaphthalene) ($C_{10}H_{18}$)—A fully saturated hydrocarbon, used as a solvent, also as substitute for lamp, motor, and lubricating oils; devoid of optical activity, with a b.p. 191·7° C., flash-point 51·6° C., ref. ind. 1·4815, and sp. gr. 0·8947. It is prepared by treating naphthalene in a fused state (at a temperature above 100° C.) with hydrogen in the presence of a catalyst such as finely divided nickel and copper oxide. It is of aromatic character, with an odour something like that of camphor, and can be used as a cleansing fluid for machinery (particularly printing machines), and for removing stains from garments. As a solvent, it is stated to be equal to turpentine, and it is somewhat slower in evaporation than that liquid, which is a point in its favour for some applications. (See "Tetralin.")

DELIQUESCENCE—Absorption of moisture from the air, whereby substances become pasty or more or less liquid in character; common salt, for example, is a deliquescent substance, and calcium chloride is very deliquescent, the vapour pressure of its solution being below that of atmospheric aqueous vapour.

Some crystalline substances when exposed to the air combine with the moisture contained therein and pass into other distinct crystalline forms; in certain instances the combination continues to such an extent that the substance liquefies. (See Drying-Tube and Efflorescence.)

DELPHINIDIN CHLORIDE ($C_{15}H_{11}O_7Cl$) is a crystalline body which can be obtained from the pigments of the wild purple larkspur and the blue-black pansy, and the same product has been synthesized. (See Pratt and Robinson, *J.C.S.*, cxxvii., 166-175.)

DELPHININE (Delphinin) ($C_{31}H_{49}NO_7$)—A white, crystalline, poisonous glucoside, soluble in alcohol and ether, contained in stavesacre seeds and extracted from the herb *Delphinium staphisagria*, or larkspur; used in ointment or lotion form to destroy *pediculi*. The seeds of *Delphinium ajacis* contain 1·83 per cent. alkaloids and *D. elatum* 1 per cent. These

DELPHININE (*Continued*)—
all belong to the so-called Hellebore group. (See K. Kondu, *B.C.A.*, 1928, A, 1256.)

DENATURANTS—Substances introduced into alcohol, made for general use and industrial purposes, to prevent its consumption as drink—such as paraffin oil, pyridine, camphor, naphtha, nitro-benzol, pine oil, benzene, and liquid diethylphthalate ($C_6H_4(CO_2C_2H_5)_2$). (See Methylated Spirits.)

DENATURED ALCOHOLS—See Denaturants and Methylated Spirits.

DENITRATION—(1) The removal of nitrogen oxides from sulphuric acid; (2) the removal or change of the nitro group ($—NO_2$) in organic compounds.

DENSIMETER—Apparatus for ascertaining the sp. gr. of liquids. (See Hydrometer.) The "Ranarex" Gas Densimeter is described (*Ind. Chem.*, 1931, vii., 41).

DENSITIES—Relative weights compared with standards. Water is taken as a standard of comparison for liquids and solids, whilst hydrogen gas is ordinarily taken as that of gases. The critical density of a fluid is that in its critical state, being the reciprocal of its critical volume. The critical temperature of water is 364° C., its critical pressure is 195 atmospheres, and its critical density 0·208. (See Critical Constants, Gases, Hydrometer, Molecules, and Specific Gravities.)

DENSI-TENSIMETER—An appliance used for measuring vapour pressure and vapour density simultaneously. (See Andreas Smits, *J.C.S.*, 1928, p. 2409.)

DENTINE—The exposed parts of the teeth (which on the whole have a bone composition), consisting of a combination of calcium and magnesium compounds and organic matter of a gelatinous character.

The following analysis is one of human teeth :

Phosphate and fluoride of calcium	66·7 per cent.
Calcium carbonate	3·4 ,,
Magnesium phosphate	1·0 ,,
Salts	0·83 ,,
Fat	0·40 ,,
Organic matter	28·00 ,,

DEOXIDATION—The removal of oxygen as a constituent of a substance; for instance, iron oxide is deoxidized by heating with carbonaceous material, as in smelting, thus reducing it to the metallic state. Barium dioxide is deoxidized to the state of barium monoxide by heating it to a certain temperature.

DEPHLEGMATE—To deprive of water or other liquids by evaporation or distillation, using for fractional separation a fractionating column or dephlegmator. The dephlegmator is so constructed that the vapour from the still is made to pass through several successive layers of the condensed distillate before reaching the condenser, thus increasing the

DEPHLEGMATE (*Continued*)—efficiency of the fractional separation of any lower boiling constituent. (See Distillation.)

DEPILATORIES—Chemicals used for the removal of hair from skins, such as the alkaline sulphides used in tanning operations. (See Tanning.)

DEPOLARIZE (Electrical)—To remove polarization in an electrical cell by the chemical action of added substances such as manganese dioxide, which reacts with the hydrogen liberated at the cathode and thus effects the desired change. (See Electricity, p. 290.)

"DERBAC" SOAP, of disinfectant character, stated to contain a high percentage of Russian birch tar, and claimed to be a curative agent for skin affections and the destruction of pediculi.

"DERBY RED"—Trade name for basic lead chromate; the deeper shades are also known as "Chinese" or "Persian" reds.

DERBYSHIRE SPAR—See Fluorine.

DERMATOL—Basic bismuth subgallate, used in medicine as an iodoform substitute.

DERRIS ROOT (*Derris elliptica*) is cultivated in Sarawak, Borneo. (See Takei and Koide (*B.C.A.*, 1929, A, 933; 1930, A, 216); Takei (with others) (*B.C.A.*, 1931, A, 847); E. P. Clark (*B.C.A.*, 1930, A, 967; *C.T.J.*, 1931, **88,** 32); and Insecticides.) Rotenone (extractable by ether or carbon tetrachloride) is regarded by Takei as the active constituent, but according to R. C. Roark it is devoid of rotenone as a constituent (*B.C.A.*, 1931, B, 514).

"DERUSTA"—A proprietary rust destroyer for use on surfaces tarred or painted with pitch, etc.

DESICCATE—To dry or denude of water. (See Drying.)

DESICCATOR—A drying appliance designed to effect dehydration—that is, the removal of water from chemical substances. A common form consists of a segmented porcelain basin containing a layer of strong sulphuric acid, standing on a glass plate having a ground surface and covered with a closed bell-jar provided with ground edges slightly coated with grease. The liquid or solid preparation to be dried (desiccated) is placed in a smaller vessel of glass, platinum, or other material on the top edges of the vessel containing the sulphuric acid, which, having a strong affinity for water, absorbs the moisture evaporated from the substance undergoing the drying process. Sometimes this appliance is coupled up with an air-pump to facilitate the process. By greasing the plate as well as the edges of the bell-jar, the combination is made airtight. (See Air-Pump and Drying.)

DESTRUCTORS—There are various makes and types of destructors available, among other purposes, for the utilization of factory refuse by way of fuel economy—for example, the "Horsfall" destructors, one of which is made to burn "washery" refuse from collieries, and the "Meldrum" destructor; while for burning mixed refuse there are larger appliances, such as the "Heenan" and the "Heenan and Froude" destructors.

DESTRUCTORS (*Continued*)—

It is estimated that some 10,000,000 tons of household refuse are produced in the United Kingdom annually in addition to several million tons of factory refuse, of which a large proportion could be usefully disposed by means of suitable destructors. (See Waste.)

DETERGENTS—See Soap and Washing.

DETONATORS—Copper tubes containing a charge of mercuric fulminate alone or mixed with potassium chlorate or other ingredients. Other detonating compounds include an aniline derivative named "tetryl" (tetranitroaniline), cyanuric triazide, lead azide ($Pb(N_3)_2$), etc. Detonation requires to be started by a strong impulse such as that imparted by the explosion of a charge of mercury fulminate; it proceeds very rapidly from layer to layer, and is due to the formation of an explosion wave having a velocity of thousands of metres per second; that for $2H_2 + O_2 = 2{,}810$ metres per second. In blasting operations detonators (like gunpowder) are either fired by a time-fuse or electrically. As a primer for detonators, lead azide is much cheaper than fulminate of mercury. (See H. L. Callendar on Dopes and Detonation (*B.C.A.*, 1927, B, 272); Haid and Koenen on "Testing Detonators" (*B.C.A.*, 1931, B, 224); W. Cullen on the "Miners' Safety Fuse" (*Chem. and Ind.*, 1931, **50,** 533); Laffitte and Patry on "Transmission of Detonation" (*B.C.A.*, 1931, A, 689); Obituary Notice *re* H. B. Dixon (*J.C.S.*, 1931, p. 3354); Azides and Explosives.)

DETRITUS—Redeposited matter worn off rocks.

DEVITRIFICATION—See Glass.

"DEVOLITE"—A proprietary brand of colloidal clay of use in the rubber, paint, and toilet articles industries.

DEWAR FLASK—See Vacuum.

DEW-POINT—The temperature at which the atmospheric air is saturated with moisture and begins, in consequence, to deposit it. (See Air.)

"DEXONITE"—A substitute for vulcanite and ebonite as an insulating material; non-corrosive and acid-resisting; sp. gr. at 60° F. 1·2765.

DEXTRIN ($C_6H_{12}O_5$) **or Starch Gum**—Ling and Nanji have shown that so-called stable dextrin can be obtained in almost theoretical yield from the products of the action of malt diastase on starch at 40° C. as a white powder which is acted on slowly by maltase to form *iso*maltose, and by emulsin, giving isomaltose and dextrose (*J.C.S.*, 1925, cxxvii., 636-651). (Compare Dextrines.)

DEXTRINES (**British Gum**)—The comprehensive name given to the varying dextro-rotatory, gummy, intermediate, hydrolytic products, including maltose and *d*-glucose, obtained from starch by heating with or without the supplemental help of acids, alkalies or diastase. In the commercial manufacture, acid is usually employed, and the procedure varied according to the nature of the dextrine or gum required. The dextrines are soluble in water, do not reduce Fehling's solution, and are not fermentable. They are largely used in the sizing of white goods, manufacture of foods, and as adhesives. By a patented method it is

DEXTRINES (*Continued*)—

claimed that great adhesive strength is given to a solution of 800 grms. dextrine dissolved in a litre of water by the addition of 200 grms. calcium nitrate. (See W. A. Darrah (*Chem. and Metallurgical Engineering*, No. 7); *C.T.J.*, 1924, **74**, 709; A. E. Williams on "Potato Dextrin (Present-day Manufacturing Methods)" (*C.T.J.*, 1932, **90**, 99); *Ind. Chem.*, 1932, viii., 114; Glucose and Starch.)

DEXTRO-LIMONENE—A terpene ($C_{10}H_{16}$) constituent of several essential oils.

DEXTRO-ROTATORY—See Polarization.

DEXTROSE ($C_6H_{12}O_6$)—A soluble carbohydrate, dextro-rotatory in character, and otherwise known as glucose and grape-sugar, prepared from cane-sugar by inversion and from starchy bodies by action of hydrochloric and other mineral acids; but, as thus made, it contains dextrine and other unfermentable bodies in association. Chemical investigations have shown dextrose to be an amylene of the nature of an oxide. In addition to starch glucose-syrup, a finely granulated white form of pure dextrose or corn sugar is now made in the U.S.A. on a large scale, possessing as it does good sweetening and preserving properties. It is largely used in brewing, confectionery, as a yeast food, preparing tobacco, and in chrome tanning liquors, and is not regarded so much as a directly competitive article with cane or beet sugar, with which for some applications it is used in association. For technical details respecting the manufacture of pure dextrose, see W. B. Newkirk (*C.T.J.*, 1924, **75**, 613); see also Glucose and Invertase.)

DHOL—A dried lentil of varying types produced in India.

DIABANTITE—An uncommon member of the chlorite group of complex mineral silicates.

DIACETINE—See Acetin, Triacetin, and Glycerol.

DIACTINIC—The property of transmitting actinic rays. (See Actinism.)

DIALYSIS—A sort of diffusion by means of which a liquid which contains, say, a crystallizable substance such as salt or sugar, with another which is not crystallizable (colloid), such as albumin or gum, can be separated. This is effected by placing the mixture in a tray or other vessel having as its bottom a sheet of parchment paper or animal membrane, such as bladder, etc., and floating or suspending this vessel in a dish of water, when the crystallizable (dialysate) substance in solution dialyses or diffuses through the parchment dialyser into the water outside, and the colloidal substance in solution remains behind in the containing vessel. Colloidal solutions are not utterly devoid of the property of diffusion, but as the size of the constituent particles is great in comparison with that of the molecules, they diffuse very slowly as compared with crystalloids. Incidentally, it may be remarked that there are dialysers specially made for the recovery of soda-lye in viscose factories amongst other applications. (See Colloid Chemistry and Osmosis.)

DIAMIDE—See Hydrazine.

DIAMINES—Organic compounds containing two animo groups, such as ethylene diamine ($C_2H_4(NH_2)_2$), a colourless liquid of ammoniacal odour which boils at 123° C. (See Amines.)

DIAMINOPHENOL ($C_6H_3(OH)(NH_2)_2$)—The ortho- and para- varieties of this substance are greyish-white and crystalline, soluble in alcohol, and used as photographic developers. (See Amidol.)

DIAMMINES—Inorganic compounds containing two NH_2 radicals.

DIAMONDS—See Carbon, p. 138.

DIAPHANOUS—Transparent to light.

DIAPHRAGMS—C. E. Marshall, in an article on "The Constants of Diaphragms," describes a general method for determining the size and number of pores in insulating material. (See Osmosis and Porosity.)

DIASPORE—Mineral alumina of composition $Al_2O_3H_2O$, crystal system, No. 4, and sp. gr. 3·5.

DIASTASE—An amorphous active principle or enzyme, soluble in water, contained in extract of malt, and capable of turning starch into soluble substances susceptible of fermentation. According to a patented method, diastase is formed by growing *Aspergillus oryzæ* upon the residue from germinated barley or wheat, alone or mixed with bran or corn from which the starch has been removed. The diastase is extracted with water or with a mixture of water and alcohol or glycerine, and precipitated from the extract with any known precipitant. It loses its activity at temperatures above 70° C. (See Beer, Enzymes, Malt, and Starch.)

DIATHERMANOUS—A character of substances like rock-crystal which transmit heat as transparent substances transmit light.

"DIATOL"—An American lacquer solvent containing 90 per cent. diethyl carbonate, made by ethylation of phosgene. It is water white, of sp. gr. 0·969 at 20° C. and devoid of objectionable odour.

DIATOMITE (Diatomaceous Earths)—Forms of kieselgühr or siliceous deposits containing water, organic matter, and other impurities of varying amounts. (See monograph on the subject issued by the Imperial Institute (H.M. Stationery Office); also *Diatomaceous Earth*, by Robert Calvert (Chem. Catalog. Co., N.Y.); and W. Hugill (*Trans. Ceram. Soc.*, 1931, **4**, 195); Kieselgühr, Silicon, and Tripoli.)

DIAZO GROUP, a bivalent (divalent) radical (—N_2— or —N : N—), as it exists, for example, in diazo-benzene chloride (C_6H_5—N : N—Cl); its introduction into a compound is styled diazotization (diazotizing), and it is usually effected in respect of primary amines using nitrous acid or any agency capable of releasing nitrogen trioxide (N_2O_3).

DIBASIC—See Basicity and Valencies.

DICHLORANILINE—An intermediate. (See Chloranilines.)

DICHLORBENZIDENE ($C_6H_3ClNH_2 : C_6H_3ClNH_2$)—A crystalline intermediate soluble in alcohol and ether.

DICHLORETHYLENE—See Solvents.

DICHLOR-ETHYL-ETHER ($CH_2Cl\ CH_2.O.CH_2CH_2Cl$)—An American solvent, b.p. 178° C., insoluble in water, but soluble in alcohol and ether, used as a constituent of liquid textile soaps, as a cleaning agent for metal, and for general use.

DICHLOROBENZENE ($C_6H_4Cl_2$)—Para-dichloro-benzene is a white crystalline intermediate, m.p. 53° C. and b.p. 173·7° C.; used also as an insecticide for peach-borer (*Ægeria Exitiosa*) control in Georgia and elsewhere. The ortho-compound also finds several industrial applications, in cleaning, as a fat solvent and spray for clothes' moths, etc.

DICHLORO-ETHANE (1 : 1) ($CH_3.CHCl_2$) (**Ethidene Chloride or Ethylidene Chloride**)—A by-product in manufacture of chloral, possessing anæsthetic properties; b.p. 57° C.; also prepared by the further chlorination of C_2H_5Cl.

DICHLOROHYDRIN (Alpha) ($CH_2Cl.CH(OH)CH_2Cl$)—A colourless liquid, sp. gr. 1·396, b.p. 174° C., soluble in alcohol and ether, prepared by interaction of dry hydrochloric acid gas and glycerine, followed by distillation; used as a solvent of nitro-cellulose and resins, and for making photographic lacquers, etc.

DICHROISM—The property possessed by double-refracting crystals of exhibiting two colours when viewed in different directions. (See Crystals and Fluorescence.)

DICYANDIAMIDE—A grey-white crystalline product used as a fertilizer, prepared by the hydrolysis of calcium cyanamide ($2CaCN_2 + 4H_2O = 2Ca(OH)_2 + (CN.NH_2)_2$) or by heating it to 150° C. (See *Ind. Chem.*, 1927, iii., 463.)

DIDYMIA—See Cerite and Praseodymium.

DIELECTRIC CONSTANT—The electro-static force mutually exercised between two electrically charged bodies varies with the medium employed, and the measure of this property constitutes the dielectric constant. Insulating materials are more or less dielectric. The unit is the dielectric constant of a vacuum; the constant for glass and sulphur, for example, is 3, and that of water nearly 80.

"DIELINE"—See Solvents.

DIESEL OIL—For qualifications of various types see H. Kühl (*Petroleum*, 1926, xxii., 977, and *B.C.A.*, 1926, B, 939); see also W. A. Tookey on "Diesel Engines," *Mechanical World Year Book*, 1932, p. 139 (Emmott and Co., Manchester).

DIET—See Foods and Feeding Stuffs.

DIETHYLAMINE ($(C_2H_5)_2NH$)—A volatile inflammable liquid, sp. gr. 0·710 and b.p. 57·5° C., prepared by action of dilute potassium hydroxide on dinitro-diethylaniline. (See Amines.)

DIETHYLANILINE ($C_6H_5.N(C_2H_5)_2$)—A yellowish-brown, inflammable liquid of sp. gr. 0·935 obtained by heating a mixture of aniline, aniline hydrochloride, and ethyl alcohol. It boils at 213·5° C., is soluble in alcohol and ether, and employed in the manufacture of "malachite green" and other synthetic dyes.

DIETHYL SULPHATE [$(C_2H_5)_2SO_4$]—A colourless, non-poisonous, non-inflammable liquid of faint ethereal odour, sp. gr. 1·185, and b.p. 96° C. at 15 mm. pressure. It begins to decompose slowly above 150° C., and deposits crystals upon cooling to $-24{\cdot}5°$ C. Upon boiling with water (with which it is non-miscible) it is hydrolysed into ethyl alcohol and sulphuric acid. It is used for the ethylation of other substances, and in the preparation of ethyl chloride, bromide, and iodide.

One process for preparing it is by the vacuum distillation of the product obtained by mixing ethyl alcohol and sulphur trioxide. It is not toxical, as is the corresponding dimethyl sulphate, which is used for introducing the methyl group. (See J. McLang, *C.T.J.*, 1928, **83**, 143.)

DIFFUSION—A property particularly exhibited by gases (dependent upon the kinetic energy of their molecules), all of which mix together or diffuse into each other without chemically combining and in a much more complete sense than liquids are thoroughly miscible with each other. Oxygen and nitrogen as they exist in the air are thoroughly admixed. The relative velocities of diffusion of any two gases are inversely as the square roots of their densities. (See Gases.)

Gases will also diffuse through thin plates of metal—as, for example, hydrogen through nickel. Solid substances have to a large extent to be forcibly mixed together to effect a mixture, and even then such a mixture is never an absolutely perfect one. Diffusion, however, between solid bodies can take place. Austen-Roberts, for example, has shown that when an alloy of lead and gold containing 5 per cent. gold is pressed tightly against a cylinder of pure lead heated to 165° C. for thirty days, some gold passes into the lead cylinder. Some diffusion takes place even at 100° C., and more freely at higher temperatures, but well below the melting-point of lead. Gold will also diffuse into silver at 800° C.; copper will diffuse into solid nickel; and cylinders of copper and zinc heated for some six or eight hours at 400° C. form a yellow alloy to a depth of 0·8 mm.

Some metals—tin and lead, for example—which melt or fuse upon being heated sufficiently, can in this condition be mixed together. Similarly, fats melt on the application of heat, and when melted they can be mixed together (admixed). (See P. Henry on "Diffusion of Solids," *B.C.A.*, 1926, A, 895; Alloys Dialysis, Gases, Metals (Calorizing and Sherardizing), Miscibility, Osmosis, Porosity, and Solids.)

DIGEST—To steep in or expose a substance to the digestive action of a solvent liquid.

DIGESTION (Animal)—See Saliva, Chyme, Chyle, Bile, Gastric Juice, and Pancreatic Juice.

DIGITALIS—A genus of plants (Scrophulariaceæ) occurring widely in England and Europe, of which the common foxglove is the best-known species (*Digitalis purpurea*), containing as active principles glucosidal substances known as digitoxin and digitalin. The leaves of *D. lanata* have a greater physiological activity than those of *D. purpurea*. Digitoxin is stated to be crystalline, of m.p. 255° to 257° C., soluble in water, and actively poisonous. Digitalin, to which the formulæ

DIGITALIS (*Continued*)—

$C_{27}H_{46}$ O_{14},$C_{35}H_{56}O_{14}$ and $C_{37}H_{58}O_{14}$ have been variously given, has been described as an amorphous substance of m.p. 210° to 217°, and less physiologically active than digitoxin. Another constituent, named digitonin, is reported to have the composition $C_{55}H_{90}O_{29}$, and to be resolved by hydrolysis as follows: $C_{55}H_{90}O_{29} + 5H_2O = C_{26}H_{42}O_5$ (digitogenin) $+ 4C_6H_{12}O_6$ (hexose) $+ C_5H_{10}O_5$ (pentose).

One account relative to digitoxin and associated bodies is that given by Windaus and Freese, who describe a method of preparation and give it the formula $C_{42}H_{66}O_{13}$; see *B.C.A.*, 1926, A, 153; A. Windaus (*B.C.A.*, 1926, A, 1146, and *B.C.A.*, 1929, A, 299); and Jacobs and Gustus (*B.C.A.*, 1929, A, 798). Another investigation would appear to indicate the presence in the leaves of the following substances: digitoxin ($C_{44}H_{70}O_{14}$); gitalin ($C_{17}H_{28}O_6$), m.p., 245° C. (optically inactive); and bigitalin, $C_{40}H_{64}O_{14}$, m.p., 282° C. (optically inactive). (See M. Cloetta, *B.C.A.*, 1926, A, 775.) Windaus and Haack have assigned the formula $C_{36}H_{56}O_4$ to *digitalinum verum* from analyses of the hexa-acetyl derivative $C_{36}H_{50}O_{14}Ac_6$ (*B.C.A.*, 1929, B, 543).

A recent examination of the glucoside contained in the leaves of *D. lanata* has been made by Sydney Smith (*J.C.S.*, 1930, pp. 508 and 2478, and 1931, p. 23), who describes it as a new one of the empirical formula $C_{41}H_{64}O_{14}$, which he names as digoxin and which yields upon hydrolysis products as represented—$C_{41}H_{64}O_{14} + 3H_2O = C_{23}H_{34}O_5 + 3C_6H_{12}O_4$—viz., digoxigenin and the sugar digitoxose. This digoxin appears to be identical in composition with the substance previously described as gitoxin. Mannich, Mohs, and Mauss have, so they report, isolated four glucosides, neither of which is identical with Smith's digoxin, from the alcoholic extract of the dried leaves of *D. lanata*, the principal glucoside being represented as $C_{41}H_{66}O_7,4H_2O$, of m.p. 245° C., and named lanadigin (*B.C.A.*, 1930, A, 1561). See also Jacobs and Gustus (*J. Biol. Chem.*, 1930, **86**, 199; *Ibid.*, **88**, 531) and Jacobs and Fleck (*Ibid.*, **88**, 545).

It is obvious that the chemistry of digitalis constituents calls for further investigation.

The herb itself and various preparations made from it are used in medicine as diuretics and for retarding circulation.

Some particulars of the composition of digitalis seed are given by S. H. Culter (*B.C.A.*, 1930, A, 1628).

DIKA BUTTER (**Cay-Cay Butter**)—Obtained from the kernels of certain species of the oil-bearing *Irvingia*. The product obtained from *Irvingia gabonensis* of Africa is known as dika butter, while the *I. oliveri* of Asia gives a similar product called cay-cay butter.

Dika butter melts at 38·9° C., has a sp. gr. of 0·914 at 40° C., a sap. v. of 244·5, and i.v. 5·2. It contains mainly lauric and myristic acids and a small percentage of oleic acid; has edible value, and is of some importance in the chocolate industry, and can be used in soap and candle making, etc. The residual cake resembles copra cake, and can be used for animal consumption. (See Collin and Hilditch, *J.S.C.I.*, 1930, **49**, 138 T).

DILL-SEED OIL—Distilled from the seeds of *Anethum graveolens*, a genus of Umbelliferæ, cultivated in England, East India, Germany, and Russia; yield 3 to 4 per cent. It contains limonene and 40 to 60 per cent. carvol, has a sp. gr. of from 0·895 to 0·92 at 15° C., opt. rot. +70° to +80° at 20° C., and ref. ind. 1·477 to 1·488 at 25° C. It is soluble in alcohol and ether, of pale yellow colour and characteristic odour, and used in perfumery and for flavouring. An allied fruit is collected in India and Japan (*Peucedanum sowa*), but its oil has a higher sp. gr.—viz., 0·945 to 0·997.

DILUENTS—Liquids used for diluting or thinning solutions by addition thereto.

DILUTION LAW (**Ostwald's**)—See Solution.

DIMETHYLAMINE [$(CH_3)_2NH$] is present in Peruvian guano and produced by action of alkalies on nitroso-dimethyl-analine. (See Amines.)

DIMETHYLANILINE ($C_6H_5.N(CH_3)_2$)—An oily derivative of aniline of b.p. 192° C., sp.gr. 0·954, possessing a strong basic character; it solidifies in the cold, and is used in the synthetic manufacture of dyes. By a process of mild oxidation it is converted into methyl violet, and by a process of reduction it yields the dye "malachite green."

DIMETHYLBUTADIENE—See Rubber.

DIMETHYL SULPHATE [$(CH_3)_2SO_4$] is a colourless liquid of sp. gr. 1·35 and b.p. 188° C., with a pleasant ethereal odour, used for methylating amines and phenols in the dyestuffs and synthetic perfumes industries, and has also been used as a military poison gas. It is prepared by distillation *in vacuo* of a mixture of methyl alcohol and fuming sulphuric acid. It is very poisonous; its fumes produce violent inflammation of the larynx, bronchial tubes, and eyes, whilst the liquid blisters the skin and produces bad sores.

DIMORPHOUS—See Crystals.

DINITROBENZENES ($C_6H_4(NO_2)_2$) (**Meta-** m.p. 90° C., **Ortho-** m.p. 118° C., **and Para-** m.p. 372° C.)—Yellow crystalline intermediates, soluble in alcohol, produced by the action of strong nitric acid on benzene, strong sulphuric acid being added to absorb the water formed during the nitration.

DINITRO-CHLORO-BENZENE ($C_6H_3(NO_2)_2Cl$)—A colourless, crystalline intermediate which in common with chloropicrin has been found capable of determining substantial crop increases, but whether by destruction of harmful organisms, increase of nitrate production, or direct stimulation of plants is not yet known. It is prepared by chlorination of dinitrobenzene and is soluble in alcohol.

DINITROPHENOL (**Alpha**) ($C_6H_3OH(NO_2)_2$)—A yellow crystalline body, slightly soluble in water, soluble in alcohol and ether, prepared by nitration of phenol; used in the dye industry, also for making picric acid and as a fungicide for rubber, etc. (See Nitration and Explosives.)

DINITROTOLUENE ($C_6H_3CH_3(NO_2)_2$)—A yellow crystalline intermediate (2 : 4, 3 : 4, and 3 : 5), soluble in alcohol and ether.

DIONIN (Ethyl Morphine Hydrochloride)—See *C.T.J.*, 1928, **83,** 143.

"DIOXAN"—See Solvents.

DIOXIDES—Compounds containing two proportions of oxygen to one of base—as, for example, barium dioxide (BaO_2).

DIOXIMES—Compounds containing two oxime groups, such as benzil dioxime, $(C_6H_5)_2C_2(N.OH)_2$. (See Oximes.)

DIPENTENE (Optically Inactive Limonene) ($C_{10}H_{16}$)—A sweet-smelling terpene constituent of several modifications occurring in some essential oils, for instance citronella oil and *Oleum cinæ* (in which it is associated with lineol). It can be produced from pinene by the influence of dilute alcoholic sulphuric acid or from sylvestrene and other terpenes by several methods. Sp. gr. 0·85, b.p. 181° to 182° C.

DIPHENYL ($C_6H_5.C_6H_5$)—A crystalline colourless substance which can be synthesized by several methods and produced by passage of benzene vapour through a red-hot tube. It is a constituent of coal tar and readily soluble in alcohol and ether; m.p. 71° C.; b.p. 254° C.; sp. gr. 0·9845. It is used in the oil industry as a vapour-phase heat-transfer medium, being non-corrosive and stable at 800° F. Its use as a starting-point in organic synthesis, including benzidine, carbazole, etc., has been described by Morgan and Walls (*J.C.S.I.*, 1931, **50,** 94 T).

The commercial article is stated to be stable at from 460° C. to 482° C., with a critical temperature of about 536° C., and without action on iron and steel.

DIPHENYLAMINE [$C_6H_5)_2NH$]—A colourless, crystalline intermediate, soluble in alcohol and ether; m.p. 52·85° C.; distils at 302° C.; prepared by heating aniline and aniline hydrochloride at from 210° to 240° C.

DIPHENYL-METHANE ($C_6H_5.CH_2.C_6H_5$) is derived from methane by replacement of two hydrogen atoms by two phenyl groups. It is crystalline, colourless, having a pleasant orange-like odour, soluble in alcohol and ether, and of m.p. 26° C.

DIPPEL'S OIL (Bone Oil)—A dark brown mixture of sp. gr. 910-970 of unpleasant odour obtained to the extent of from 5 to 10 per cent. by destructive distillation of bones from which the fat has not been previously abstracted. It contains, amongst other constituents, ammonia, ethyl benzene, pyridine, pyrrole, and is utilized as a source of pyridine and some alkaloids, whilst the pyrrole can be extracted in the form of a potassium combination (C_4H_4NK), from which it is obtained by treatment with water. Bone oil is also used in making bone-black and as a denaturant. (See Bone-Black.)

"DISCOL"—A motor fuel of alcoholic character made from molasses.

DISEASES (INDUSTRIAL)—See Dr. Legge's articles in the Annual Factory Reports for 1923 to 1925, and Dr. Bridges' Reports for 1926 to 1931 (H.M. Stationery Office); also Occupational Matters, Pitch and Poisons.

DISINFECTANTS—A great number of chemical preparations are used as disinfectants for many different applications, the term disinfection being taken here to mean all measures for the security of health against infection. They include hydrogen dioxide, potassium permanganate, bleaching powder, hypochlorites, sulphur dioxide, formaldehyde, creosote, phenol, phenoloids, xylenols, etc.; "Okol," "Izal," "Bactox," "Creocide," "Jeyes' Fluid," "Sanitas Fluid," "Sanitas Oil," a number of essential oils, and many other proprietary articles and chemical substances including some dyes, and which are for the most part described severally under their respective names in this work. Some are poisonous, or have staining or corrosive properties or other disabilities for certain applications, but are yet available for special purposes; and it follows of necessity that no one preparation can be used for all applications, choice being made according to qualifications and the nature of the case. Some act as germicides, some by antiseptic action, others by destructive oxidation of the poisonous products of germ life, others again by rendering the media unfit for germ life, thus bringing about its destruction, etc; so that germicidal efficiency alone is not an exclusive test of real efficiency. There are no chemical tests available for determining their *comparative* values apart from those applicable to small limited classes, such as coal-tar preparations, to which alone the much over-rated Rideal-Walker test applies, and even in that one respect, their respective values depend entirely upon their suitabilities and efficiencies for particular purposes. (See "Bacterial Testing of Disinfectants," by Kingzett and Woodcock, *Pharm. J.*, July 30, 1910; and *Analyst*, xxxviii., 190; article on "Coal-Tar Disinfectants," by A. C. Tait (*C.T.J.*, 1926, **79**, 619); also Antiseptics, Bacteria, Dyes, and Germicides.)

DISINTEGRATORS—Machines for grinding, granulating, or shredding materials. (See Grinding.)

DISPERSION—(1) A term used in connection with colloid chemistry. (See Colloid Chemistry.)

(2) The separation of light into its different coloured rays. (See Light (Spectroscope).)

DISPERSOIDS—See Colloid Chemistry and Osmosis.

DISSOCIATION—Spontaneous or forced acts of decomposition. For example, when steam is heated sufficiently, it is forcibly decomposed into hydrogen and oxygen, or, in other words, its constituent elements are dissociated. Phosphonium chloride (PH_4Cl), below 0° C., is completely dissociated into phosphine (PH_3) and hydrochloric acid (HCl). Ozone is resolved into oxygen at 246° C., and ammonium carbonate on exposure to the air breaks up, or is dissociated, into ammonium bicarbonate and ammonia.

Electrolytic dissociation is referred to elsewhere. (See Electricity (p. 292) and Ionization.)

DISSOLVE—See Solution.

"DISSOLVED ACETYLENE"—See Acetylene.

DISSYMMETRY—See Asymmetry and Crystals.

DISTEMPERS—See Paints.

DISTILLATION—The process of converting a substance into vapour and then recondensing same by cooling. As applied to liquids, it may be termed "wet distillation," but the method is also used in respect of many volatile solid substances, and it is then termed "dry distillation or sublimation." For example, sulphur, metallic mercury, and zinc can be distilled. Distillation under vacuum is sometimes resorted to in order to lower the temperature at which it can be conducted, the advantage lying in the fact that by reducing the pressure, the disparity of temperature between the applied heating and the boiling liquid is exaggerated, and consequently there is an increased transmission of heat per square inch of heating surface. Many liquids whose boiling-points are higher than that of water can be distilled in a current of steam passed through them, and sometimes it is advantageous to employ it in a superheated state and in conjunction with reduced pressure (partial vacuum); these conditions are generally observed in carrying out the distillation of essential oils, shale oils, glycerine, etc.

"Destructive distillation" means the subjection of materials to heat to such an extent that they are decomposed, and it is the products of this destructive distillation that pass over from the retorts and are condensed fractionally or collectively. This occurs in the cases of resin distillation, coal distillation, the distillation of wood, and the "cracking" of petroleum.

Fractional Distillation affords the means of separating, more or less, the several constituents of mixed distillable liquids by collecting the portions or fractions which pass over at varying temperatures. For example, alcohol boils at 78° C. and aniline at 185° C., so that a mixture of the two substances can be separated by this process. One apparatus for effecting such separations is known as the Gooderham fractionator. *References:* T. H. Pope (*Chem. and Ind.*, 1931, **50**, 318) on fractional distillation; "An Improved Receiver for Vacuum Distillation," by G. A. R. Kon (*J.C.S.*, 1930, p. 182); a still for liquids of high b.p. by K. Hickman (*Chem. and Ind.*, 1929, **48**, 365); a "Distilling Apparatus for the Chemical Engineering Laboratory," by W. L. Beuschlein (*B.C.A.*, 1929, A, 418); the "Hird" continuous tar distillation plant (*Ind. Chem.*, 1930, vi., 105); the "Wilton Pipe Still" or "Dehydrator" (*Ibid.*); C. H. Butcher on "Stills and Fractionating Columns" (*Ind. Chem.*, 1930, vi., 95 and 139); C. H. Butcher on "Coils for Steam-heated Stills" (*Ibid.*, 1930, vi., 199); Photograph of Welded Fractionating Columns (*Ind. Chem.*, 1932, viii., 118); *Principles and Practice of Industrial Distillation,* by E. Hausbrand, translated by E. H. Tripp (Chapman and Hall); *The Elements of Fractional Distillation,* by C. S. Robinson (McGraw-Hill Publishing Co., Ltd.); *Distillation Principles and Processes,* by S. Young (Macmillan and Co., Ltd.); also Boiling-Point, Dephlegmate, and Retorts.

DISTILLED WATER—See Water.

DISTILLERY WASTE LIQUIDS (**Purification**)—See R. D. Littlefield (*Chem. and Ind.*, 1925, **44**, 860) and Waste Power and Products.

DISULPHIDES—Compounds containing two proportions of sulphur to one of base, as, for example, carbon disulphide (CS_2).

DIVALENT—See Valencies.

DIVI-DIVI—The dried seed pods of *Cæsalpinia coriaria,* indigenous in tropical America, of growing importance in the tanning industry; capable of yielding as much as 300 lbs. of pods per season, and containing a very astringent tannin ranging from 40 to 45 per cent. Venezuela is the most important source, and the Goajira Peninsula of Colombia ranks next.

DOLOMITE—A rock consisting of varying proportions of calcium and magnesium carbonates, of crystal system, No. 3, and sp. gr. 2·8 to 2·9. It can be utilized to some extent for the manufacture of refractory bricks by admixture with suitable binders and fluxes. Sodium silicate solution and dextrine-water mixtures give good results as binding agents. (See Magnesium and Refractories.)

DOPES—Various solutions or varnishes used in the aeroplane and cinema industries, etc., made by dissolving cellulose or cellulose compounds in certain solvents, including acetone; amyl alcohol; amyl, butyl, and ethyl acetates; dichlorethylene, trichlorethylene, tetrachlorethylene (perchlorethylene), tetrachlorethane, and pentachlorethane. A small proportion of boric acid is sometimes added to cellulose dopes in order that they may retain their viscosity. It has been stated that 5 to 8 per cent. of ammonium phosphate or ammonium-magnesium phosphate added to cellulose nitrate renders it fire-resistant, and qualifies it to compete with cellulose acetate as an aeroplane dope. (See *Manufacture, Use, and Storage of Cellulose Solutions,* Factory Department, Home Office Form 826 (H.M. Stationery Office); Maurice Deschiens (*Chem. and Ind.,* 1925, **44,** 902); H. T. S. Britton (*Ind. Chem.,* 1927, iii., 116); F. Sproxton on cellulose ester varnishes (E. Benn, Ltd., London); Cellulose Solvents, Films, Lacquers, and Viscose.)

DOPPLERITE—A peculiar brownish-black, jelly-like material found infrequently at some distance below the surface of peat-bogs, being a colloidal body belonging to the so-called ulmin compounds resulting from the decay of vegetable matter. Two published analyses are as follows:

	Dull.	Brilliant.
Carbon	57·90	56·70
Hydrogen	5·31	4·92
Oxygen	34·00	36·60
Nitrogen	2·10	1·10
Sulphur	0·70	0·70

Upon drying it acquires a hard, shiny appearance similar to that of the vitrain of banded bituminous coal. (See Coal and Peat.)

“DORSITE”—An activated carbon. (See p. 142.)

“DOUCIL”—A proprietary, compound aluminium silicate water-softening material of the base-exchanging character, and admitting of regeneration by treatment with a solution of common salt. Its approximate composition is $Na_2O,Al_2O_35SIO_2$. (See “Permutit” and Water-Softening

DOVER'S POWDER—A preparation made from ipecacuanha, opium, and potassium sulphate, and used as a sedative and sudorific.

DRAGON'S BLOOD—See Balsams, and Gums and Resins.

DRAUGHT (Mechanical)—See book by Lister and Harris (E. Benn, Ltd.).

DRIERS—See Drying, Oils, Siccatives, and Varnishes.

“DROP BLACK”—Residual bone-black from the sugar-refining industry, washed and ground for use in the paint and enamel trades.

DROP-BOTTLE—A simple appliance for providing drops of liquids for testing purposes, consisting of a bottle fitted with a long, tapered, solid glass stopper, so that when the stopper is withdrawn a small quantity of the liquid adheres to it, and may be dropped into any solution or on to any solid substance to be tested. Another somewhat similar arrangement is that of a hollow tube or small pipette that passes through the cork, and is drawn out to a fine point at the lower end. By use of a compressible rubber bulb attached to the upper end of the tube, as much of the liquid as is desired may be drawn up in the tube, and ejected therefrom as required. A simple form constructed on the siphon principle is described by P. Fuchs (*B.C.A.*, 1929, A, 1415).

DRUGS (CHEMISTRY OF)—See A. J. Clark on “Drugs Manufactured by the Body” (*Chem. and Ind.*, 1930, **49**, 533), N. Evers (*Chem. and Ind.*, 1927, **46**, 131); and books by N. Evers (Ernest Benn, Ltd.), N. Evers and G. D. Elsdon (Chas. Griffin and Co.), and J. E. Driver and G. E. Trease on the *Chemistry of Crude Drugs* (Longmans and Co.); also Pharmacy.

DRY CLEANING—See illustrated description of Achille-Serre, Ltd., Works (*Ind. Chem.*, 1931, vii., 325).

DRY ICE—See Carbon Oxides, p. 146.

DRYING—Drying of solids can be effected to a considerable extent by pressure, and there are well-understood methods of drying applicable to liquids and gases. So-termed “spray drying” is carried out by means of a spraying device which carries the finely divided substance into a chamber in which it encounters a current of hot air, causing evaporation and deposition of the dry product in the chamber. Any escaping powder carried away by the current of air is recovered by filters. There are two types of spraying devices—viz., one which acts by stationary nozzles and the other by means of centrifugal force. In film drying the liquid is passed over the heating surface in the form of a thin film.

Drying plant comprises many designs (some of a rotary and others of

DRYING (*Continued*)—
a centrifugal character) and a number of them are described in the articles listed below: "Some Notes on their Design," by C. H. Butcher (*C.T.J.*, 1929, **85,** 389, 487, and 619), C. H. Butcher (*Ind. Chem.*, 1928, iv., 47, 91, 135, 199, 355, and 415); "Vacuum Drying" (*C.T.J.*, 1928, **83,** 545); J. W. Hinchley on "Drying by Pressure" (*C.T.J.*, 1929, **84,** 3); J. A. Reavell on "Spray Drying" (*Chem. and Ind.*, 1927, **46,** 925 and 951), and "Film and Spray Drying" (*Trans. Inst. Chem. Engineers,* 1928, Vol. 6, p. 115); "Krause Process of Spray Drying," by F. A. Oetken (*B.C.A.*, 1932, B, 83); J. E. Nyrop (*J.S.C.I.*, 1929, **48,** 136 T); T. B. Philip (*J. Inst. Chem.*, February, 1930); L. L. Bircumshaw on "Drying of Gas Streams" (*J.C.S.*, 1930, p. 2213); the electrically heated "Abderhalden" drier by E. P. Clark (*Ind. Eng. Chem.*, March, 1928); A. T. Henley, "Notes on Tunnel and Stove Plant Drying" (*C.T.J.*, 1928, **83,** 499); A. Alison, "Removal of Water during Concentration" (*Ind. Chem.*, 1930, vi., 402); "The New Jenkins' Centrifugal Dryer" (*Ind. Chem.*, 1932, viii., 77); E. P. Clark (*Ind. Eng. Chem.*, March, 1928); P. K. Sherwood (*B.C.A.*, 1929, B, 1035); *C.T.J.*, 1927, **81,** 451; *Ind. Chem.*, 1927, iii., 104, 494, and 561, and Centrifuges.

DRYING, INTENSIVE—See Heat, p. 436.

DRYING-OILS—See Oils and Linseed Oil.

DRYING-OVEN—See Water-Oven.

DRYING-TUBES—Appliances used for drying gases, some being straight or other shaped tubes packed with small lumps of calcium chloride ($CaCl_2$), which substance has a great affinity for moisture. Another variety consists of a **U**-shaped tube sealed at the bend with strong sulphuric acid, as it also has the property of absorbing moisture contained in gases bubbled through it, such, for example, as those which are generated by burning organic substances in a current of dry air or oxygen. The increase in the weight of the tube gives the weight of the water absorbed, from which may be calculated the proportion of hydrogen contained in a known weight of the organic substance employed. An improved form of **U** tube is described (*Chem. and Ind.*, 1927, **46,** 1222); another by D. Hardy (*J.C.S.*, 1929, p. 1108); see also *Ind. Chem.*, 1928, iv., 168, and Organic Analyses.

DRY ROT—See Wood.

DUCO—A lacquer of the cellulose nitrate solution type. (See M. J. Callahan, *J.S.C.I.*, 1928, **47,** 222 T.)

DUCTILITY—Easily drawn into wire (malleable). (See Metals.)

DUGONG OIL—See Fish Oils.

DULCITOL (**Dulcin, Dulcite**) ($C_6H_{14}O_6$ or $C_6H_8(OH)_6$)—A white, sweet, crystalline, saccharine body, obtained from the dried herb *Melampyrum memorosum* at the flowering time and the red seaweed *Bostrychia scorpioides* (Haas and Hill); soluble in water and isomeric with mannite (mannitol). (See Galactose.)

DULONG AND PETIT'S LAW—See Heat.

"DULUX"—Name of some new synthetic resin products, including vehicles for pigments in paint-making and an oil finish.

"DURALUMIN"—An alloy, sp. gr. 2·85, containing more than 90 per cent. aluminium, 0·5 per cent. magnesium, and some proportions of copper, iron, and manganese (3·0 to 4·5 per cent. Cu; 0·4 to 1 per cent. Mg; 0 to 0·7 per cent. Mn; and remainder commercial aluminium containing iron and silicon). The age-hardening of alloys of this type is said to be primarily due to the magnesium silicide (Mg_2Si) content. (See papers on the metallurgy of this alloy by J. Mather and M. Pubellier, respectively (*B.C.A.*, 1930, B, 424), and Scleron.)

DURANTHRENE COLOURS—Derivatives of anthra-quinone, being colours of excellent fastness, suitable for dyeing vegetable fibres in all stages of manufacture.

DURENE or *s*-**tetramethyl-benzene** ($C_{10}H_{14}$ or $C_6H_2(CH_3)_4$) is a colourless crystalline body of m.p. about 80° C., and b.p. about 190° C., occurring in coal tar. It has a camphoraceous odour, and can be made from toluene or xylene by several processes.

"DURIMET"—An American acid-resisting metal, being steel of several grades containing proportions of nickel, silicon, chromium, and carbon. (See *Ind. Chem.*, 1929, v., 407.)

"DURIRON" METAL—An American, acid-resisting metal, containing about 14 per cent. silicon and small proportions of manganese, carbon phosphorus, and sulphur.

"DUROGLASS"—A trade name for borosilicate chemical-resistance glassware of high thermal endurance.

"DUROPRENE"—A proprietary article (heptachloride of rubber), prepared by the combined action of bromine and chlorine on rubber and used in compounding paints or varnish for the prevention of rust on metals, etc. It is a greyish-white powder, soluble in benzol, naphtha, and carbon tetrachloride, and easily moulded when warmed.

"DUROSIL"—A chemical glass, free from lead, arsenic, and antimony.

DUSTS AND DUST EXPLOSIONS—Investigations made by the U.S.A. Bureau of Mines have shown that—

1. 0·2 ounce coal dust per cubic foot of air will propagate an explosion.
2. Using a long flame explosive of black powder or dynamite may cause ignition of a coal-dust cloud.
3. Dust-laden air will explode when either quiescent or moving near the lighting flame, even when saturated with moisture, provided enough dust be present in the air.

Dust explosions are not confined to coal, but extend to atmospheric mixtures of many other ignitable substances, such as starch, meal, flour, cake refuse, sugar, etc., if the proportions of dust and air lie (as in the case of gas) within certain limits.

It is stated that dust particles which float in the air cannot be much

DUSTS AND DUST EXPLOSIONS (*Continued*)—

larger than 0·001 cm. diameter, "smokes" being defined as systems in which the particles are driven about the gas in Brownian motion. (See Colloid Chemistry, p. 225.)

Precipitated calcium carbonate has been advocated by A. C. Dunningham as approximating most nearly to the ideal substance for stone dusting of mines and as preferable to shale dust.

"Comparative Tests of Instruments for Determining Atmospheric Dusts" (*U.S.A. Public Health Bulletin,* 1925, No. 144) is the subject of an article in the *Analyst,* 1926, **51,** 36. The dust problem and its solution is the subject of a paper entitled "Aerosols in Industry," by W. E. Gibbs (*C.T.J.,* 1925, **77,** 441; and *J.S.C.I.,* 1926, **45,** 177 T and 183 T). A method for the rapid determination of dust in air, based upon the retention of the dust in sugar solution and a subsequent measurement, is described by McHair and Hirst (*J.S.C.I.,* 1929, **48,** 127 T). Dust removal from gases is referred to under the heading of "Cottrell Precipitating Plant." As to dust explosion risks, see R. V. Wheeler (*Chem. and Ind.,* 1931, **50,** 650); *Safety in Mines Research Board Paper,* No. 48 (H.M. Stationery Office); *Memo. on Dust Explosions,* compiled by Factory Department of the Home Office (H.M. Stationery Office); *C.T.J.,* May 13 (p. 624) and July 11 (p. 33), 1924; *The Dust Hazard in Industry,* by W. E. Gibbs (E. Benn, Ltd., London); see also Coal, Mists, and Particles.

DUTCH LIQUID—See Ethylene Dichloride.

"DUTCH METAL"—An alloy of copper and zinc prepared in leaf form in imitation of gold leaf.

"DUTCH WHITE"—White lead.

DYADS—See Valencies.

DYER'S BROOM (*Genesta tinctoria*)—Found in pastures and thickets in Southern Europe, Russian Asia, Southern Sweden, and some parts of Great Britain and North America. It contains two principles, one of which is a yellow colouring matter of crystalline character and another named genistein ($C_{14}H_{10}O_5$), which can be obtained in the form of colourless crystals.

DYES AND DYEING—There are thousands of dyes, in addition to mineral pigments, some being natural products, such as cochineal, barwood, brazil-wood, madder, indigo, logwood, peach-wood, cutch, gambier, fustic, sumac, annatto, and safflower, of which descriptions will be found under their respective names; but for the most part they are chemically (synthetically) produced substances from coal-tar sources.

The manner in which dyes become attached to the fabrics varies according both to the chemical constitution of the fabrics themselves and those of the dyes employed. In some cases, definite compounds are formed by the action of the dyes on the fabrics; in other cases, "lakes" are formed by the agency of mordants, the precipitated substances being thus directly attached to the fabrics; and in yet other cases

DYES AND DYEING (*Continued*)—

the dyes are developed on the fibres. Basic dyes (salts of colourless bases) containing amino groups, including mauve, magenta, methylene blue, malachite green, and Bismarck brown, are fixed on cotton goods by the use of acidic mordants. Acidic dyes, including picric acid, azo-scarlets, and aniline blue, are attached to wool and silk goods by the use of an acid-bath. Some acidic dyes, such as alizarin red and others in the form of sodium salts of the sulphonic acids, require the use of a metallic mordant. Dyes of a saline nature, like the Congo-red and primulin series, are used for cotton and linen without any mordant, and there are pigment dyes, such as chrome yellow, synthetic indigo, and aniline black, in respect of which the colour is developed on the fibres.

The dyestuffs are also classed as "substantive" and "adjective," the former having the property of dyeing fibres directly, while the latter only colour them permanently when used in association with mordants.

Vat dyestuffs comprise a series of insoluble bodies admitting of reduction to alkali-soluble leuco compounds, many being derivatives of anthracene, but benzene and naphthalene are more economical sources. Naphthalene, for instance, can be converted into phthalic acid by partial burning in air, and the product can be caused to condense with benzene to yield anthraquinone, which can be used instead of anthracene for the preparation of the better class of vat dyestuffs. They are applied in their leuco (colourless) compounds, the colour in the fibre being subsequently developed by oxidation, and include notably methane derivatives of triphenylmethane dyestuffs. The anthraquinoid vat colours are of particular value in cotton dyeing owing to their fastness to light and washing. The best-known indigoid vat dyestuffs is indigo itself. In wool-dyeing the insoluble dyestuffs are now almost invariably rendered soluble by use of hydrosulphites, which reduces them to leuco-compounds. (See L. J. Hoohey (*Chem. and Ind.*, 1925, **44,** 2); J. Ferguson (*Ind. Chem.*, 1925, i., 171); J. Wilson (*J. Soc. Dyers and Colourists,* October, 1927); G. K. Palmer (*Ind. Chem.*, 1925, i., 398); and C. M. Whittaker (*J.S.C.I.*, 1932, **51,** 66 T).)

The azo dyes are a large class containing one or more so-called azo groups (—N : N—) linking together aromatic radicals. Many of them dye cotton without the use of a mordant, while others act as very fast dyes on wool. They may be regarded as originating from the red crystalline parent substance azobenzene ($C_6H_5 : N : N.C_6H_5$) or its homologues, all its basic and acid derivatives being colouring matters. The basic ones contain NH_2 or $N(CH_3)_2$ groups and the acidic ones either phenolic (OH) or sulphonic ($SO_2.OH$) and phenolic groups.

Azobenzene itself is obtained from nitrobenzene by reduction of a solution of that substance in ether containing water, by means of sodium amalgam.

Group compounds containing such as —N : N— or NO_2 are known as chromophores and produce dyes when introduced into so-called chromogens—that is, compounds which contain unsaturated groups of C_6 arranged as in benzene. (See Chromogens and Chromophores.) The azo dyes are grouped in four divisions—monazo, disazo, trisazo,

DYES AND DYEING (*Continued*)—

and tetrakisazo—the first two of these being subdivided into those which contain benzene nuclei only, those containing benzene and naphthalene nuclei, and those containing naphthalene nuclei only. (See Clement Whitehead on "Azo Dyestuff Technology" (*C.T.J.*, 1925, **77,** 33, 92, 152, 206, 265, and 386) and Arnold Schedler (*J.S.C.I.*, 1925, **44,** 392 T).)

The sulphur group, produced by the fusion of amidated aromatic compounds with sulphur or by heating a variety of organic bodies with sulphur and sodium sulphide, are of more or less unknown constitution. They include the "Indo-Carbon C.L.," and many are made from dinitrophenol ($C_6H_3(NO_2)_2OH$), "sulphur black" being made from it by action of sodium sulphide and sulphur. (See *C.T.J.*, 1926, **79,** 498; J. H. Platt (*Ind. Chem.*, 1926, ii., 458); and J. L. Crist (*C.T.J.*, 1927, **81,** 302).)

A new series prepared by direct action of various vapours such as benzene over or through molten sulphur is described by G. D. Palmer, jun., and S. J. Lloyd (*B.C.A.*, 1931, **50,** 476).

Black and dark-coloured dyestuffs are also produced by condensing amino derivatives with highly halogenated vat dyestuffs followed, if desired, with further ring closure (L. J. Hoohey, *Ind. Chem.*, 1930, vi., 29).

The so-called "ciba" and "cibanone" vat dyes are indigo derivatives containing bromine.

Previous to dyeing, cotton and wool are subjected to purifying and bleaching treatment. (See Bleaching.)

Wool absorbs colours and mordants much more readily than cotton, while silk can be dyed with coal-tar colours by mere immersion in an aqueous or alcoholic solution. As a rule, cotton goods will not dye without previous treatment with a mordant, the mordant in such cases directly combining with, and thus fixing the dye and the mordants used; for acid dyes, feeble bases like aluminic, chromic, and ferric hydroxides (which are produced on the fabrics by immersing them in solutions of the acetates of these bases and steaming them) are used, the colours of the "lakes" so produced varying with the base employed. Using basic dyes for cotton goods, these are first mordanted with tannic acid or a tin salt, such as the chloride.

Fastness to washing and light is obtained in some cases by the action of metals—copper and chromium solutions, for example—on the colours. The atmospheric fading of dyestuffs is not exclusively due to the action of light: humidity, temperature, the chemical character of the atmosphere, perspiration, and other factors exercising influences, and ultra-violet rays of very short wave-length are very destructive.

One class of dyestuffs is available for dyeing either silk or artificial silk only, so that when used in a bath with another dyestuff, as, for instance, "chlorazol blue," in respect of a mixed material of, say, cotton and silk-substitute, the cotton fibres will be dyed blue and the silk "effect" threads will be dyed yellow. These substances are derivatives of "primulin" and are termed ionamines. (See "Icyl.")

DYES AND DYEING (*Continued*)—

Furs have to be dressed by a tannage treatment before dyeing, and after "wetting out" they are "killed" by steeping in or brushing with a dilute alkaline solution such as ammonia, soda, or lime, this being done to kill the resistance exhibited by the hair to the action of the dye. They are then mordanted by steeping in some solution of a metallic salt such as copper sulphate, sodium dichromate, alum, iron sulphate, etc., and finally dyed either by immersion or a brushing process. Paraphenylene-diamine and similar compounds are among those used for the dyeing of hair.

Certain dyes, such as the strongly basic crystal violet, possess definite antiseptic properties, and particularly some which contain one or more amino groups, while the azo group (which constitute the largest section of synthetic colours) exhibit little antiseptic activity. Several dyes—*e.g.*, "Nile blue" (of the oxazine series)—will kill protozoa in such high dilution as 1 in 20,000 without harming bacteria, and hence it is thought that such agents may be employed to destroy them in the activated sewage disposal process without destroying the bacteria, upon the activity of which the successful conduct of that process depends. Acriflavine and a product named "Rivanol" (ethoxy-diamino-acridine-hydrochloride) are claimed to be powerful antiseptic agents, as also auramine. (See Green and Copland (*C.T.J.*, 1927, **81,** 505); and Antiseptics.)

References: Dyeing by "colloidal solubilisation" or "dispersion" (S.R.A. Colours); see G. Holland Ellis (*J. Soc. of Dyers and Colourists*, September, 1924) and Silk Substitutes; figures of the various main classes of dyes of British production (*C.T.J.*, 1930, **86,** 421) and further information by H. Sutcliffe Smith (*Chem and Ind.*, 1930, **49,** 627, and 1931, **50,** 640); an account of the manufacture of some dyestuffs in Huddersfield (*Ind. Chem.*, 1925, i., 81); article on the dyestuffs industry, by Rex Furness (*Chem. and Ind.*, 1929, **48,** 827); the subject of "Union Dyeing"—that is, materials consisting of a mixture of various fibres—by H. Wilkinson (*Ind. Chem.*, 1925, i., 298); "The Dyeing of Ribbons," by L. Eastwood (*Ibid.*, 1927, iii., 32); "The Dyeing of Millinery Materials," by E. Gilfson (*Ibid.*, 1928, iv., 223); "Some Notes on Dyestuff Selection and Fastness Data," by J. Ferguson (*Ibid.*, 1925, i., 518); "A Modern British Dye Factory" (*Chem. and Ind.*, 1925, **44,** 1218); "The Dye-house" (*Ind. Chem.*, 1927, iii., 21); Report of lecture by G. T. Morgan on "Mordant Dyestuffs" (*C.T.J.*, 1925, **77,** 716); "The Progress of the Dyestuff Industry in 1927," by R. S. Horsfall (*Ind. Chem.*, 1928, iv., 11); reviews of the dyestuff industry (*Ind. Chem.*, 1929, v., 6; 1930, vi., 29; 1931, vii., 16; and by R. Brightman, 1932, viii., 17); J. Engi (*J.S.C.I.*, 1931, **50,** 266 T); J. Blair on "Dyestuffs Manufacture" (*Chem. and Ind.*, 1932, **51,** 197); H. Levinstein (*J.S.C.I.*, 1931, **50,** 251 T); *Dyeing with Coal-Tar Dyestuffs*, by C. M. Whittaker (Baillière, Tindall and Cox); *A Textbook of Dye Chemistry*, by Von Georgievics and Grandmongin (E. Benn, Ltd., Lond.); *Chemistry of Dyeing*, by J. K. Wood (Gurney and Jackson, London); *Dyeing and Cleaning*, by F. J. Farrell (C.

DYES AND DYEING (*Continued*)—

Griffin and Co., Ltd.); see also Colours, Caledon Dyes, Flavone, "Indigosol O," Intermediates, Plant Colouring Matters, Nigrosines, Quinoline, Rosanilines, Safranines, Textiles, and Triphenylmethane.

DYNAMITE—See Explosives.

DYNAMO—See Electricity.

DYNAMOMETER—Apparatus for measuring force, such as that of muscular effort or of a motor.

DYNE—See Force.

DYSPROSIUM (Dy)—Atomic weight, 162·4. An exceedingly rare and but little known element occurring in *gadolinite.*

DYSTECTIC MIXTURE—The correlative of eutectic mixture, being a mixture of definite proportions of two or more substances of constant melting-point, constituting the maximum melting-point of any mixture of them. The addition of any one of the constituents lowers the m.p.

EARTH—The third planet in order from the sun, its substance being that of the chemical elements and their compounds. The mean density of the earth has been experimentally determined as 5·6747 times that of water. (See Matter and Soil.)

EARTH-NUT OIL—See Arachis Oil and Nut Oils.

EARTH WAX (**Cerasine**)—See Waxes.

EARTHENWARE—See Porcelain.

EAU DE COLOGNE—A popular solution of various essential oils (including neroli, bergamot, citron, lavender, lemon, orange, and rosemary, etc.) in alcohol, prepared as a perfume by many recipes; a small quantity of the oil of Malabar cardamoms is sometimes incorporated.

EAU DE JAVELLE and EAU DE LABARRAQUE—Dilute solutions of potassium and sodium hypochlorites at one time commonly used in France for bleaching and disinfecting purposes. They can be severally prepared by treating a solution of calcium hypochlorite with one of potassium or sodium carbonate and filtering off the precipitated calcium carbonate. (See "Chloros," Dakin's Solution, and "Milton.")

EBONITE—See Rubber (Vulcanite).

EBONY—The black heart-wood of *Diospyros ebenum,* which grows in Ceylon, Madagascar, etc., is the best-known variety, of which there are a number of kinds derived from various species.

EBULLIOSCOPE (**Ebuliscope**)—An apparatus for determining the boiling-points of liquids; also for determining the alcoholic strength of solutions by means of the temperatures at which they boil. Another form is described (*Ind. Chem.*, 1927, iii., 328); see also W. Swientoslawski (*B.C.A.*, 1927, A, 42, and *B.C.A.*, 1931, A, 1388).

EBULLITION—Boiling.

ECHITAMINE (DITAINE) ($C_{22}H_{28}O_4N_2$)—A crystalline alkaloid contained in the bark of *Alstonia scholaris* R. Br., and other similar species. (See Goodson and Henry, *J.C.S.*, 1925, cxxvii., 1640.) It melts at 105° C., and is soluble in water, alcohol, and acetone.

EDUCT—A body or cleavage product, separated or brought to light by the splitting up, as by hydrolysis, of a more complex substance in which it previously existed in chemical association, and not otherwise originated by the decomposition.

EFFERVESCENCE—Escape of gas from a liquid or mixture—as, for example, when hydrochloric acid is poured on marble, carbon dioxide gas is evolved; or as, again, when soda-water (which is water charged under pressure with the same gas) is allowed to escape from a siphon.

EFFLORESCENCE—Salts which lose a part of their water of crystallization on exposure to the air, and thereby become coated with a pulverulent deposit due to this change, are described as efflorescent. Common washing soda ($Na_2CO_3 10H_2O$), for example, by efflorescence loses 9 out of its 10 molecules of water and becomes reduced to the carbonate of sodium (of different crystalline form) represented by the formula Na_2CO_3,H_2O. That is because its vapour pressure is greater than that of the atmospheric aqueous vapour; on the other hand, some crystalline salts, such as cupric sulphate ($CuSO_4,3H_2O$), absorb moisture from the air. (See Crystals and Deliquescence.)

EFFLUENTS (TRADE)—The rôle of lime in the treatment of these effluents is dealt with in an American article by R. H. Ferguson, reproduced in the *C.T.J.*, August 29, 1924; see also *Ibid.*, 1929, **84**, 533; Ammonia-Still Effluent, Distillery Waste Liquids, Gas (p. 388), Kier Boiling (p. 513), Paper (p. 671), Sewage, Sugar (pp. 867-869), Sulphur (p. 882), Tannery Waste (p. 892), Viscose Effluent (p. 813), Waste, Wool Industry Effluents (*C.T.J.*, 1931, **89**, 627), and Wool (Washing, pp. 998 and 999).

EGGS are nutritious articles of food. Eggs for storage should not be more than a week old, and the temperature should be between 0° and 0·6° C., the air being kept humid, with free circulation; evaporation of the egg moisture can be checked by use of various coating solutions, aluminium soap in pentane being one mixture recommended (T. Moran and R. Piqué, H.M. Stationery Office, 1926). Dried egg contains from 38 to 40 per cent. oil and phosphatides, about 44 to 44½ per cent. albuminoids, and 4 to 5 per cent. carbohydrates.

The shell of birds' eggs consists for the most part of calcium carbonate (about 90 per cent.), calcium and magnesium phosphates (about 6 per cent.), and animal matter and sulphur (about 4 to 5 per cent.).

The white of egg is albumin, whilst the yolk is of complicated composition, containing fatty matters, lecithin (a phosphatide present in brain matter), cholesterol (about 1·36 per cent.), etc. Hens fed on white food, such as rice, are stated to lay eggs with white yolks.

EGGS (*Continued*)—

The eggs and roes of fishes are, to some extent, of somewhat similar composition, and equally valuable as foods.

Both the albumin and the yolks of eggs are used in many industries. The yolks of eggs can be preserved without change in the nature of their coagulation if the temperature be not allowed to fall below −6° C.; they can be used in soap-making, as, apart from the olein contained in them, the constituent lecithin is decomposed by hydrolysis as follows:

$C_{42}H_{84}NPO_9 + 3H_2O = C_3H_9PO_6$ (glycero-phosphoric acid) + $C_5H_{15}NO_2$ (choline) + $C_{18}H_{34}O_2$ (oleic acid) + $C_{16}H_{32}O_2$ (palmitic acid),

and the last two named acids become converted into soap.

A protein substance named "livetin" is stated to be present in egg yolk, in addition to lecitho-vitellin, and that it has the properties of a pseudo-globulin.

Lecithin is used, to small extent, in compounding some margarines.

EGO OIL—From seeds of "Egonoki" (*Styrax japonica*), indigenous in Japan. (See *Analyst*, 1930, **55**, 153.)

n-**EICOSANOIC ACID** ($C_{19}H_{39}.COOH$)—A constituent of Rambutan tallow, the fatty constituent of the seeds of *Nephelium lappaceum;* it can also be prepared from erucic acid.

EKA—Prefix being the Sanscrit numeral one. Gallium is the element which Mendelejeff predicted by name "eka-aluminium."

ELÆOPTENE—See Stearoptene.

ELÆOSTEARIC ACIDS (α and β) are stated to be stereo-isomeric linolenic acids. The constitution of the α variety is alleged to have been proved as $CH_3.(CH_2)_3.(CH:CH)_3.(CH_2)_7.CO_2H$. (See Tung Oil.)

ELAÏDIC ACID—See Oleic Acid.

ELASTICITY—Capability of being stretched and resumption of original shape and dimension upon cessation of the force used to alter the original form.

ELECTRIC BATTERIES (Furnaces, Lamps, Light, Motors, Radiators, Telegraph, Telephone)—See Electricity.

ELECTRICAL PRECIPITATION OF GASES—See Cottrell Precipitating Plant.

ELECTRICITY (**and Magnetism**)—Electricity, like heat and light, has in the past been generally regarded as a form of energy, often, if not always, produced by or involved in chemical actions. Indeed, it was at one time chiefly produced by chemical means, using what are called voltaic batteries. Some physicists regard the interplay of electricity and magnetism as "the fundamental action of the universe," manifesting itself as light, heat, and radiation of all kinds. (See Sir W. Bragg, Faraday number of *The Times*, September 21, 1931, p. viii.)

ELECTRICITY (*Continued*)—

Helmholtz considered it probable that electricity is atomic in character in a material sense, while Sir Joseph Thomson is supposed to have proved that so-called negative electricity is atomic in structure, and exists in indivisible units now named electrons, carrying a certain electric charge and having a certain mass, as constituents of all chemical atoms. An electrically neutral atom which has lost one or more electrons is called a positive ion, and neutral atoms which have lost or gained electrons are said to be ionized. All the same, we are not bound to believe in the material nature of electricity, as there are other ways of interpreting the phenomena in question. (See Atoms, Elements, and Radio-activity.)

A stick of sealing-wax, a glass rod, or a piece of amber rubbed briskly upon the coat sleeve becomes electrified, and in this state can pick up bits of paper. There are machines which produce electricity by friction, as, for example, when a plate of glass is made to revolve rapidly between two cushions of cloth.

Lightning is a discharge of electricity (as revealed to the senses by accompanying light and sound) from clouds charged with it; and just as heat can be conducted by metals, so can electricity, as utilized in the use of telegraphic cables. So-called lightning conductors are attached to tall buildings and chimney-shafts to protect them against destruction: they are generally made of copper with pointed ends, and carry the electric force into the earth or water, with which they should be connected at the lower end.

If a plate or rod of metallic zinc and another of metallic copper be placed in a glass jar containing dilute hydrochloric acid and allowed to touch each other or be connected by, say, a piece of copper wire, a chemical interaction is seen to take place. The zinc is attacked by the acid, although the copper appears to be unaffected; the acid is decomposed and hydrogen gas is given off from the surface of the copper, owing to the zinc having a greater affinity for the chlorine of the hydrochloric acid than the copper. The explanation, so far as it is understood, is complicated; but it may be said that the two metals assume opposite electric states: a current of electricity (voltaic current) flows away from the zinc and carries the hydrogen gas to the copper, from the surface of which it is discharged. (See J. A. V. Butler on "The Seat of the Electromotive Force in the Galvanic Cell" (*Chem. and Ind.*, 1926, **45,** 3). The copper is called the positive pole or *anode,* and the zinc the negative pole or *cathode,* and, to prove that a current of electricity is really passing from one to the other, it is only necessary, instead of allowing the two plates to touch each other, to connect the two metals under these circumstances with a fine thread of platinum wire in the place of one of copper, when—because it is not such a good conductor of electricity, and therefore offers more resistance to its passage—it becomes red-hot, showing that the electric discharge, being impeded or obstructed, is transformed to some extent into heat.

This is an instance of chemical change producing electric energy, and such an arrangement is styled a galvanic or voltaic element. The

ELECTRICITY (*Continued*)—

wasting of the zinc furnishes the energy, and the quantity of electricity that passes is proportional to the amount of chemical action, which is represented by the equation: $Zn + 2HCl_4 = ZnCl_2 + H_2$.

A *battery* consists of a number of such elements or cells grouped up together.

In the "*Grove*" *battery*, which is often used in chemical laboratories, the outer cell (made of glass or ebonite) is charged with dilute sulphuric acid (1 : 7) and a zinc plate (the surface of which is amalgamated with mercury to moderate the action of the acid on the zinc); while in the inner, or porous cell, a thin sheet of platinum, immersed in strong nitric acid, serves as the negative pole. The zinc being attacked by the sulphuric acid liberates hydrogen, which in passing through the nitric acid decomposes it, producing water and nitric peroxide (N_2O_4) gas.

The "Bunsen" carbon battery is constructed of an oblong prism of carbon, a zinc cylinder, a porous pot, glass cell, and binding clamp. In this modification of Grove's battery, the carbon replaces the platinum sheet, and is connected with the zinc of the next cell by means of a copper strip.

A third form, which finds more general use and is of special service for working electric bells and telephones, is the "*Leclanche*" *battery*. In this, zinc-carbon cells are employed; that is to say, each cell consists of a glass vessel in which is placed a block or plate of carbon (charcoal) and a block or rod of metallic zinc, immersed in a solution of sal ammoniac (ammonium chloride) dissolved in water. In place of the ammonium chloride, magnesium chloride or calcium chloride may be used. On connecting the carbon and zinc parts with wire, the cells become active and an electric current is generated. The zinc, in dissolving, forms a double chloride of zinc and ammonium, and ammonia gas and hydrogen are liberated at the carbon pole. To prevent so-called *polarization*—that is, interference caused by the accumulation of a layer of bubbles of gas on the carbon pole (which would interfere with the satisfactory working of the battery)—the carbon block or plate is packed inside a porous pot with fragments of carbon and powdered manganese dioxide (MnO_2), which acts as a depolarizer.

From some experiments made by V. A. Kostjejev it would appear that ammonium tartrate is a better electrolyte (*C.T.J.*, 1930, **87**, 344); and V. A. Kostjejev (*B.C.A.*, 1931, B, 166).

In the "Daniell" cell, a rod of amalgamated zinc is immersed in dilute sulphuric acid and a plate of copper in a solution of copper sulphate, the two solutions being kept separate by means of a pot of unglazed earthenware, but which allows the passage of the ions from one vessel to the other. The dilute sulphuric acid is gradually changed into a solution of zinc sulphate and the copper sulphate into dilute sulphuric acid, metallic copper being at the same time deposited on the copper plate.

In the electrolysis of copper sulphate, the positively charged atoms (cations) of copper pass to the cathode (where the current leaves),

ELECTRICITY (*Continued*)—

there giving up their charges which pass back through the wire to the battery; and the metallic copper is deposited on the cathode; while the negatively charged SO_4 radical ions (anions) move to the anode by which the current enters), giving rise to the formation of sulphuric acid and free oxygen as represented by $SO_4 + H_2O = H_2SO_4 + O$.

There are a number of ways of grouping batteries of cells. If joined up in one row ("series form"), the current generated in terms of ampères is no greater than that of a single cell, but the electromotive force (volts) is so many times greater. When joined up in "parallel form"—that is to say, all the zincs together and all the coppers (or carbons) together—the electromotive force is no greater than that of a single cell, but they yield a greater quantity or so many times more current.

There is reason for believing that thermo-electric currents occur in a single homogeneous metal—such, for example, as mercury—and not only where two distinct metals are present.

An electric current is capable of breaking up or decomposing many chemical substances in a state of solution, and this process is described as *electrolysis*. The poles of an electric battery or the terminals carrying an electric current into and out from a liquid are termed electrodes, and the substance broken up (decomposed) is termed the electrolyte. The term electrolyte is used, however, in a wider sense and applied to any substance the solution of which will conduct the electric current. A moderately strong solution of hydrochloric acid (HCl) is resolved by electrolysis into hydrogen gas which is given off at one pole, and chlorine gas which is evolved at the other pole. Water can be similarly broken up into its constituent parts, and the resulting elements are always produced in their equivalent proportions—1 part of hydrogen, for example, being accompanied by 35½ parts of chlorine when hydrochloric acid solution is decomposed as above referred to.

For a description of the various cells used in industrial electrolysis for the production and refining of metals, the production of gases, and of organic and inorganic compounds, etc., see A. J. Hale (*Chem. and Ind.*, 1924, **43,** 1224, 1250, and 1291); *Chem. and Ind.*, 1925, **44,** 131; C. L. Mantell (*Chem. and Met. Eng.*, 1931, **38,** 88); H. K. Moore (*Chem. and Ind.*, 1925, **44,** 1086); pamphlet issued by the International Electrolytic Plant Co. (Chester) concerning the Knowles' cells for producing hydrogen and oxygen; also Sodium (Caustic Soda).

Faraday showed that the charge of electricity carried by a univalent ion is independent of the nature of that ion, and that a divalent one carries exactly twice and a trivalent one three times this quantity —in other words, in terms of the atomic theory, the atoms that are equivalent to each other in their ordinary chemical action have equal quantities of electricity naturally associated with them.

The attraction between electrical charges varies inversely as the square of the intervening distance.

It has been represented that electricity consists of a mass of electrons, and that an electric current is merely a flow of electrons in stream-

ELECTRICITY (*Continued*)—

like movement along a conductor which is looked upon as stuffed full of loose electrons; further, that an electric wave is a travelling system of electrical force, but this hypothetical description does not give an adequate explanation of observed electrical phenomena.

Solutions of electrolytes, such as acids, bases, and salts, are supposed to be made up of vast numbers of electrically charged particles (ions), part positively and an equal number negatively charged, by which the electrical current is conducted, and these polarities are designated in chemical symbols by a dot (·) or a plus sign (+) in association therewith in the case of cations, while anions are represented by an apostrophe (') or minus sign (−). The splitting up into cations and anions is variously termed electro-dissociation, ionic dissociation, and ionization. It is these charges of electricity which differentiate ions from the free elements. Aqueous solutions of sugar and urea are examples of non-electrolytes. (See S. Arrhenius on the "Theory of Electrolytic Dissociation" (Faraday Lecture, *J.C.S.*, 1914, pp. 1414-1426); *The Conductivity of Solutions and the Modern Dissociation Theory*, by C. W. Davies (Chapman and Hall, Ltd., London); and Voltameter.)

The amount of a substance in a state of solution decomposed by an electric current is proportional to the amount of electricity, so that the same current passed through solutions of silver nitrate, copper sulphate, gold trichloride, and tin tetrachloride will cause the deposition of 108 mgrms. of silver, 31·8 mgrms. copper, 65·7 mgrms. gold, and 29·8 mgrms. tin, and these quantities multiplied by their respective valencies (1, 2, 3, and 4) give their respective atomic weights. Gramme equivalent weights therefore require the same amount of electricity to deposit them—viz., 96,540 coulombs.

The modern view of atoms under which the valency depends upon the number of units of negative electricity in the external sphere of the atom is regarded as a direct consequence of Faraday's law, to the effect that the amount of an ion liberated in a given time is proportional to the current. (See Faraday, p. 298, and Atoms.)

The electric current which is generated by chemical or other means can be conducted or carried away by metallic wires or rods in the form of a current and utilized as such, or can be transformed into heat, as in electric radiators, or into power by means of electric motors. (See *Electrolytic Conduction*, by F. H. Newman (Chapman and Hall, Ltd.)

The art of electro-plating of metals is dependent upon the deposition of metals such as nickel, gold, copper, and cadmium from their various solutions on to other metals, as effected by electrolysis. In silver-plating, for example, the articles to be plated are, after careful cleansing from oil, oxide, sulphides, etc., hung in the solution of a silver salt, and plates of pure silver are also placed in the same liquid, a current of electricity being passed in through the silver plates and out from the iron or other articles to be plated. In this way the pure silver is gradually dissolved and deposited as a coating on the spoons, forks, or other

ELECTRICITY (*Continued*)—

articles which it is desired to plate. Zinc and lead are extensively used for electro-plating, especially in the preparation of military supplies, as for lining gas shells, etc.

The "Einstein" process is one for the electro-plating or deposition of metallic coatings on various materials, including paper, fabrics, bone, wood, rubber, and other non-conducting materials generally. It is stated to render articles corrosion-proof and of good appearance by suitable preparation and finishing with a coating of chromium. The process is the subject of a number of patents.

The "Pigache" process is one that is used in association with the Einstein process. (See S. Wernick on the "Udylite" process of cadmium plating (*Ind. Chem.*, 1928, iv., 234); on "The Prevention of Corrosion by Electro-deposition" (*Ind. Chem.*, 1929, v., 106 and 524); and on the "Progress of Electro-deposition Industry in 1929" (*Ibid.*, 1930, vi., 57).)

A description of the "Fescol" process of electro-deposition of metals (mainly nickel, chromium, copper, and cadmium on other metals) and an account of the works of Messrs. Fescol, Ltd., is given in the *Ind. Chem.*, 1928, iv., 405. This process is stated to give perfect adhesion and the deposition of thicker deposits than other methods of electro-plating. (See also *Modern Electro-Plating*, by W. E. Hughes (Oxford University Press, London); and Handbook issued by W. Canning and Co., Ltd., Birmingham.)

As opposed to metals which are good conductors of electricity, other substances show a resistance or incapability of conductivity, and such non-conducting materials are employed in the construction of so-called *insulators;* for example, the porcelain blocks or cups that are used on telegraph posts for carrying the electric wires, so that the current is not wasted by being conducted away from the wires; and for the same reason telegraph cables are covered with gutta-percha or other non-conducting material.

It has been pointed out that most of the insulating materials in general use are of colloidal character, thus suggesting some connection between that state and the insulating property (W. H. Nuttall, *Chem. and Ind.*, 1928, **47**, 1217).

The phenomena of magnetism and electricity exhibit striking analogies. The mineral known as *loadstone* (magnetic oxide of iron) possesses the power of attracting iron as a natural property, and magnetic power is used in chemical industry for purposes of separation and concentration. Steel is easily magnetized by contact with a magnet, and it then has the property of attracting or drawing towards its poles a needle or piece of iron placed near to it. Nickel and cobalt are also magnetic. Certain substances, when under the influence of a magnetic field, can bring about the rotation of the plane of polarized light. Magnetism acts not only at a distance, but also through paper or silk or glass; thus, if a needle be placed on a thin sheet of paper or glass, a magnet moved about under the paper or glass attracts and draws the needle in whichever direction it moves. The whole earth acts as a

ELECTRICITY (*Continued*)—

magnet, and its magnetic poles, although not identical with the geographical poles, are in their near neighbourhood. Consequently the mariner's compass, being a magnetized needle and placed upon a pivot, always points one end to the north and the other to the south. The ease with which iron or steel can be magnetized by electricity is utilized, as will be presently shown, in the construction of electro-magnetic machines (dynamos).

Oliver Lodge has expressed the difference between electric and magnetic lines of force as follows: while an electric line "has two ends, a positive end on a proton, a negative one on an electron," a magnetic one is "always a closed loop," one that can be stretched, expanded, or shrunk, the electric force being composed of the north and south-seeking kinds in equal amounts, the act of magnetization of another article (such as a piece of steel) opening them out and making them perceptible. Electric currents exhibit magnetic effects, and magnets can be employed in such wise as to enable energy to generate an electric current. Both magnetism and electricity are forms of force, allied and indestructible except as to the form assumed. Some substances, including bismuth, antimony, copper, and phosphorus, are repelled from the poles of a magnet, and these are described as diamagnetic in character. The explanation of such phenomena is given in all well-known works dealing with electricity and magnetism. "Diamagnetism and Molecular Structure" was the subject of a lecture by C. V. Raman (see *Chem. and Ind.*, 1929, **48,** 1248); "Magnetism and Crystal Structure," one by W. F. Ehret (*Chem. and Ind.*, 1930, **49,** 96); see also "Magnetic Susceptibility and Chemical Investigation," by J. F. Spencer (*J.S.C.I.*, 1931, **50,** 37 T); *Electro-Magnetic Theory,* by O. Heaviside (E. Benn, Ltd., London); also Force.

Electric currents are known to exist in the muscles and nerves of animal structures, and are doubtless connected with the chemical changes that occur in living bodies. Cats emit electricity, and in dry frosty weather little sparks can be seen to pass from the standing fur of their coats to the hand when stroking them. An accident has been reported to the effect that a basket full of cats dropped into ordinary illuminating gas generated so much electricity as to cause an explosion thereof in contact with air.

Several water animals produce electric discharges, and in particular may be mentioned the *Raia torpedo* (or electric ray), found in the Mediterranean and Atlantic, which possesses an electric organ on the back of its head; whilst the *Gymnotus electricus* (or Surinam eel) has an electric organ running along the whole length of its body, and is capable of giving a terrible shock.

The discovery by Faraday that currents of electricity can be induced in a conductor by moving it between the two poles of a magnet has, in course of time, led to the construction of the magneto-electric machines known as *dynamos,* or electric generators and electric motors—appliances now extensively used for many commercial purposes.

Dynamos are machines for converting mechanical power into elec-

ELECTRICITY (*Continued*)—

trical power, and have, of course, supplanted the use of voltaic batteries in all cases where large applications of electricity are required.

They produce electricity by the rapid rotation of an *armature* made of iron and wound round with coils of insulated wire, between (but not touching) the two poles of a fixed magnet round which are also wound coils of insulated wire, it having been found that the magnetism and consequent electric current is intensified by this wrapping of copper wire or sheet when an electric current is sent through it. The rotation of the armature can be effected by using the power of waterfalls, or steam, gas, and oil engines. The water of high altitudes, when used, is conveyed by pipe lines to water-turbines working at high pressure coupled to the generators, every 2·34 feet of altitude producing a pressure of 1 lb. per sq. inch.

The current of electricity thus generated flows alternately in opposite directions as the coils pass the two poles of the fixed magnet; but a device called the *commutator* (placed on the same shaft as that which carries the armature) has collecting brushes attached to it, and these gather up and cause the current to flow in one and the same direction.

The electric motor is constructed on the same general principle, but in this case the electric current is used to cause the rotation of the armature, which in its turn is employed as a propellant for the machinery with which it may be connected, and in this way the electricity employed is converted into mechanical power.

The electric *telegraph* enables the user to transmit signals by means of an electric current to distant places, the movements or sounds made at one end of the wire being reproduced at the other end. These movements or sounds are interpreted by an understood code, and in some cases the messages are printed in type or ordinary letters.

The *telephone* is another electro-magnetic contrivance by means of which an electric current passing through or along a wire reproduces at the far end, or receiver, movements corresponding to those produced in the transmitter by the sound waves of the voice.

The *microphone* also transforms sound waves into waves of electric currents which, being transformed into electric waves in space, are used in broadcasting.

For further details as to the construction of the electric telegraph, telephone, and dynamos, see Southern's *Electricity and the Structure of Matter* (Oxford University Press).

Electric *lights* are of two classes—viz., the *arc* light and the *incandescent* light. In the former, the electric current passes from an upper rod of carbon to a lower one across the space which is maintained between them, producing a cloud of carbon vapour which, being intensely heated, forms a luminous arc of flame or light. In incandescent lamps, on the other hand, the filament or thread of carbon or metal which is made luminous is contained within a glass vessel from which the air has been removed. If these lamps were not exhausted of air, carbon threads would be destroyed by combustion with the oxygen contained in the air. As it is, the current flows in at one end

ELECTRICITY (*Continued*)—

of the filament and out at the other, and heats it to a state of incandescence. In other words, so much of the electric current is transformed into heat and light in consequence of the resistance offered to its passage. Carbon filaments are no longer used for lighting, metallic ones of various kinds having replaced them to great advantage. In these lamps, instead of a vacuum, an inert gas such as nitrogen or argon is now generally employed, which ensures a higher illuminating power with equal current consumption, tungsten being the metal almost exclusively employed for making the filaments. (See Lamps (Electric) and Tungsten.)

A leading-in wire for glass vessels recently patented in the U.S.A., having a co-efficient of expansion nearly the same as that of glass, comprises an alloy of 80 per cent. Fe, 10 per cent. Co, and 10 per cent. Mo. (See F. Friederich, *B.C.A.*, 1930, B, 150.)

The so-called *storage batteries* do not really store up the electric current which is passed into them: the current used for charging them effects certain chemical changes in the contents of the storage cells of such a character that when the electric current is shut off, the storage cells act as voltaic batteries in consequence of further new chemical changes that then take place. In other words, when they are used, they run down or undo the changes effected by the electric charge and restore the contents of these cells to their original condition, thus preparing them in due course to be treated with a new charge of electricity. (See Julius Grant on "An Improved Type of Accumulator" (*Chem. and Ind.*, 1925, **44,** 502); description of the "Tungstone" type (*C.T.J.*, 1925, **77,** 688; *Chem and Ind.*, 1929, **48,** 652); an account of the "Wilderman Separators" in Electric Batteries (*Chem. and Ind.*, 1927, **46,** 46); Heap and McKinnon (*Chem. and Ind.*, 1929, **48,** 689); Kirkman and Watson Mann (*C.T.J.*, 1932, **90,** 158); and A. J. Allmand on the "Drumm Cell" (*Nature,* March 12, 1932, abstracted in *C.T.J.*, 1932, **90,** 282).

Electrolytic methods are largely used in the extraction of certain metals from crude materials; the separation of metals; for refining copper, silver, gold, etc.; for the manufacture of a great number of inorganic and organic compounds, including chlorine, hydrogen and oxygen gases, sodium, magnesium, calcium, aluminium, soda, benzidene, iodoform, diamino-phenol, and anthraquinone, etc. (See J. B. C. Kershaw (*Ind. Chem.*, 1925, i., 283, and 1926, ii., 75 and 557); S. Glasstone (*Ibid.*, 1929, v., 423, 1930, vi., 201, and 1931, vii., 139 and 209); Fr. Fichter (*J.S.C.I.*, 1929, **48,** 341 T, 347 T, and 354 T); H. J. Sand on "New Apparatus for Electrolytic Analysis" (*Analyst,* 1929, **54,** 275); Faraday number of *The Times,* September 21, 1931; *Industrial Electrometallurgy,* by E. K. Rideal (Baillière, Tindall and Cox); *Theoretical and Applied Electro-Chemistry,* by M. de Kay Thompson (Macmillan and Co.); and another work on this subject by H. J. Creighton (Chapman and Hall, Ltd.).)

The introduction of the dynamo has led to the construction of electrical furnaces, of which it is reported that 1,200 are now in operation

ELECTRICITY (*Continued*)—

in Europe and America, one of which, constructed on the principle of the arc light, exhibits a temperature of from about 3,000° to 3,600° C. Among these are the "Birkeland-Eyde," "Pauliry," and the "Schonerr." They are used, amongst other applications, for the production of carborundum, graphite, artificial sapphires, rubies, calcium carbide, silicon, fused silica ware for chemical use, the utilization of steel turnings, the remelting of nickel-chrome steel, the preparation of ferro-alloys, and the fixation of nitrogen, etc. Electric furnaces, in which the heating element consists of a metallic wire or strip, are now widely used in laboratories and workshops, and there are a variety of specially constructed ones made on the muffle and other principles. The "Ajax-Wyatt" and "Northrup" induction furnaces are of special interest to analytical and research chemists, as any objects may be conveniently heated in their containers. The "Calimite" electric furnace of rotary type, as used for burning gypsum and limestone, is described in the *Ind. Chem.*, 1926, ii., 570, and "Electric Furnaces for Heat Treatment," by A. G. Lobley (*Chem. and Ind.*, 1930, **49,** 141).

Electric motor power is now largely used in industry, one machine of high efficiency being known as the B.T.H. "no-lag" induction motor, meeting demands up to 300 h.p. and pressure up to 600 volts. The "Powerman" is a simple conversion unit which can be adapted to any make of lift or crane. (See "Electrical Drives in Chemical Works," by H. Seymour (*Ind. Chem.*, 1926, ii., 131); references to industrial electric heating (*Chem. and Ind.*, 1928, **47,** 996); and to a modern plant for the production of electrical insulating gear (*C.T.J.*, 1930, **86,** 473). Electrical precipitation processes are dealt with elsewhere. (See Cottrell Precipitating Plant.)

Quantity of electricity is measured by "ampères" and pressure by "volts," and the product of the two gives the power in "watts." "A thousand watts flowing a period of one hour is equal to one Board of Trade unit, and this is the accepted measure by which electricity is bought and sold." In a large modern generating station, one unit can be produced by the combustion of about 1¼ lbs. of good coal. 1¼ lbs. of coal = 15,625 B.Th.U. and 1 unit of electricity = 3,415 B.Th.U., so that the thermal efficiency in producing 1 unit of electricity from coal amounts to about 22 per cent., the remainder being heat lost in the process. (See R. G. Devey, *Progress*, January, 1931, published by Lever Bros., Ltd.)

Ammeter—An instrument for determining the strength of electrical currents in terms of ampères.

Ampère (Volt ÷ Ohm)—The unit of electrical current which, when passed through a solution of silver nitrate in water, causes the deposition of silver at the rate of 0·001118 grm. per second.

Coulomb—The unit quantity of electricity capable of depositing 1·1175 mgrms. of silver, and delivered by 1 ampère flowing in one second. 96,540 coulombs = 1 faraday.

Electromotive Force (E.M.F.) (Pressure Potential)—Difference of

ELECTRICITY (*Continued*)—

potential or intensity of electric current against resistance, which can be calculated when the strength of the current (I) in terms of ampères and the resistance (R) in terms of ohms are known by the formula E (volts) = I.R. The unit in which electromotive force is measured is termed the volt. When acidulated water is electrolyzed, the tendency of the separated hydrogen and oxygen to reunite sets up a resistance or E.M.F. of 1·47 volts, so that to decompose water at the ordinary temperature a battery must have an E.M.F. of at least 1·47 volts. In the same way every electrolyte requires a particular minimum E.M.F. to produce continuous electrolysis.

Faraday (= 96,540 **Coulombs**)—That quantity of electricity capable of depositing one electro-chemical equivalent in grams, an electro-chemical equivalent being the mass of substance liberated by 1 coulomb in electrolysis. That of hydrogen is 0·00001036 grm., and the equivalents of other chemical elements are represented by the figures obtained by multiplying that of hydrogen by their gram equivalents.

The gram equivalents of elements are the atomic weights divided by the valencies, except in the cases of multivalent elements, which exhibit varying equivalents according to the respective valencies.

Ohm (**Volt ÷ Ampère**)—The international unit of resistance is that offered by a column of mercury 106·3 cms. in length, 14·4521 grms. in mass, and at the temperature of melting ice, to an unvarying electric current.

Rheostats—Instruments for regulating the flow of electric currents and for measurements, thus affording the means of controlling the amount according to Ohm's law. (See Ohm.)

Thermopile (**Thermo-couple**)—An apparatus constructed upon the knowledge that an electric current (which can be measured by a galvanometer) can be produced in a closed circuit by heating the point of contact of two dissimilar metals. The electromotive force (E.M.F.) of a bismuth-antimony pair when the junctions are kept at 0° and 100° is only 0·0115 volt, but using series of such pairs so arranged that the alternate junctions can be heated, the current is increased proportionally to the numbers of pairs. Among these appliances are the "Moll" thermopiles, which give a high E.M.F. when exposed to feeble radiations, and any two of one model can be adjusted to give the same E.M.F., so that they can be used for differential work. (See Pyrometers.)

Volt (**Ampère × Ohm**)—10^8 absolute units is the electromotive force (E.M.F.) which, applied to 1 ohm, will produce in it a current of 1 ampère. (See Ohm.)

Watt (**Volt × Ampère**)—The power of an electric current of 1 ampère flowing under a pressure of 1 volt, and approximately $\frac{1}{746}$ part of 1 horse-power. (See *Elementary Lessons in Electricity and Magnetism*, by Silvanus Thompson (Macmillan and Co.); *Science in the Service of Man: Electricity*, by S. G. Starling (Longmans, Green and Co.); *Electricity and the Structure of Matter*, by L. Southerns (London: Oxford Univ. Press, Humphrey Milford).)

ELECTRO-CHEMISTRY—See Electricity and Organic Compounds.

ELECTRO-DEPOSITION—See Electricity.

ELECTRO-GILDING—See Electricity and Gold.

ELECTRO-MAGNETIC WAVES—The whole range of electrical waves from the shortest to the longest "wireless."

ELECTRO-OSMOSIS—See Osmosis.

ELECTRO-PLATING—See Electricity, p. 292.

ELECTRODES—See Carbon Electrodes and Electricity.

ELECTROLYSIS—See Electricity.

ELECTROLYTE—See Electricity.

ELECTROLYTIC ALKALI PROCESS—See Sodium and its compounds.

ELECTROLYTIC CELLS—See pp. 291, 460, and 656.

"ELECTRON" (Metal)—Alloys of magnesium with another metal—viz., copper, aluminium, and cadmium—of value in engineering structure.

ELECTRONS—Hypothetical conceptions of ultra-atomic particles or corpuscles carrying a negative charge of electricity, this charge being, as originally hypothesized, the smallest known. They are also supposed to exist in the free state as cathode rays and beta-particles. It is further supposed that every quantity of electricity is a multiple of this elementary charge. The mass of the electron is said to be 1,840 times smaller than the atom of the lightest known so-called element—viz., hydrogen; but from a chemical point of view, electrons must be constituent parts of atomic matter. The number of electrons in an atom is variously stated to be equal to the atomic number or approximately half its atomic weight, and the total internal energy of the electron has been given as about 500,000 volts. It is the view of Helmholtz that if the elementary substances are composed of atoms, then electricity, positive as well as negative, must be divisible into definite elementary portions behaving like atoms, a view in accordance with Sir Joseph Thomson's original statement that electricity is possessed of mass and is atomic in structure. While, however, the electron commenced its hypothetical career as a mathematical inference from physical observations in displacement of the chemical atom, it now seems to be going the same way, experiments of G. P. Thomson and C. J. Davison making it appear that it is no longer to be regarded as an indivisible unit, but as a set of electrical charges moving with a train of waves with which its charge is in resonance; the speed of the waves being definitely different from that of light waves. "The Wave Theory of Electrons" is the subject of an article by G. P. Thomson (*Chem. and Ind.*, 1929, **48,** 311), and the following quotation is extracted therefrom: "The theory indicates that the possibility of the formation of a molecule largely depends on the outer electrons of the constituent atoms being

ELECTRONS (*Continued*)—
able to take up an arrangement corresponding to a possible grouping of the electrons of a single atom."

Certain experiments have been made which are regarded as being in support of the de Broglie wave theory, according to which the velocity and wave-length are governed by the speed and the mass of the particles.

Although the electron is a something which physicists have for long regarded as having been weighed and measured, Eddington, following upon his investigations of their movement, has further disturbed matters by referring to it as a "dummy," and in any case the matter remains as yet unsettled.

If the electron is the unit of negative electricity and the proton that of positive electricity, then it follows that all the chemical elements, their compounds, and, indeed, the whole material universe, are composed of ponderable electricity. In view of certain difficulties to which reference is made in his article on this subject, P. A. M. Dirac (*Proc. Roy. Soc.*, 1930, A, **126,** 360/5; and *B.C.A.*, 1930, A, 271) has advanced a new theory which postulates only one fundamental kind of particle instead of electron and proton, assuming that protons are simply "holes" in the distribution of negative-energy protons. Whatever value these various physical or metaphysical speculations may have, chemists can still adhere to the view that matter and force (energy) are two perfectly distinct things. Matter is ponderable and cannot be destroyed; force is imponderable and also indestructible, and the two things inconvertible; all chemical and physical phenomena being explicable upon the basis of a relationed redistribution of energy and matter. (See *Electron Physics*, by J. B. Hoag (Chapman and Hall, Ltd., London, 1930); *The Electron in Chemistry*, by J. J. Thomson (Chapman and Hall), and J. S. Main Smith, *Chem. and Ind.* (*J.S.C.I.*, 1925, **44,** 944).)

The term electron is also used more generally to characterize the extremely minute particles shot off in electric discharges in gases, as well as the emissions from helium, argon, and other radio-active substances. (See Atoms, Cathode Rays, Electricity, Elements, Matter, Photons, Rays, and Radio-activity.)

"ELEKTRON" METAL—Alloys of magnesium with smaller quantities of other metals, used principally in construction of aeroplanes and motor-cars. (See *C.T.J.*, 1931, **88,** 559.)

ELEMENTS—The chemical elements as generally understood are the various entities of matter of which all chemical compounds are composed, but are only to be regarded as elemental in the sense that they cannot be split up into two or more distinct substances. From gold, for example, nothing but gold can be obtained, as distinct from a compound body like water, which can be decomposed into hydrogen and oxygen. It is, however, conceivable, and believed by many, that the elements are really compounded of one primordial matter (protyle), and only vary in character according to the physical conditions under

ELEMENTS (*Continued*)—

which they are individually recognized. (See Matter and Radioactivity.)

Most of these chemical entities are defined as metallic in character, but the non-metallic ones exist more abundantly in nature, and include oxygen, silicon, hydrogen, nitrogen, carbon, chlorine, bromine, fluorine, and iodine. The two classes of metallic and non-metallic bodies gradually merge into one another, the intermediate class being sometimes described as metalloids—arsenic, for example.

The symbols used to represent the chemical elements are for the most part abbreviations of their common names; thus, the symbol of hydrogen is H, that of nitrogen N, that of calcium Ca; but there are exceptions, and while it is a pity that these exceptional symbols are still used, it will be useful to explain the reason.

The metal antimony has the symbol Sb because the Latin name for antimony is *stibium*; lead has the symbol Pb, the Latin name for lead being *plumbum*; mercury is indicated by Hg, as the Latin name for it is *hydrargyrum*; potassium by K, its Latin name being *kalium*; sodium by Na, *natrium* being its Latin name; tin by Sn, from the Latin name *stannum*; gold as Au, from the Latin name *aurum*; iron by Fe, from the Latin name *ferrum*; silver by Ag, from the Latin name *argentium*; and copper as Cu, from the Latin name *cuprum*. (See Nomenclature.)

Classification of the Elements—The chief elements can, to some extent at least, be classified into groups in respect of certain resemblances viz., as follows:

1. *Alkali metals*, including potassium, sodium, and lithium.
2. So-called *alkaline-earth* metals, including barium, strontium, calcium, and magnesium.
3. *Halogens*, including chlorine, bromine, iodine, and fluorine; so named because they form compounds with metals analogous to sodium chloride. By combination with hydrogen they form respectively hydrochloric, hydriodic, hydrobromic, and hydrofluoric acids (HCl, HI, HBr, and HF). (See Halides.)
4. A larger group may be defined as more definitely metallic than those in classes 1 and 2, and include aluminium, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, iron, lead, magnesium, manganese, mercury, nickel, platinum, silver, tin, vanadium, and zinc.
5. Those better known in their gaseous state—viz., hydrogen, helium, chlorine, fluorine, oxygen, nitrogen, and argon.
6. The non-metals, including all the elements in classes 3 and 5, also boron, sulphur, carbon, phosphorus, and silicon.

Carbon is peculiar as being the one essential element of all so-called organic compounds, whilst silicon is one of the most abundant elements found in nature. Apart from the carbonates of the metals, most of the other compounds containing carbon are known as *organic* compounds, and, indeed, organic chemistry is sometimes defined as the chemistry of carbon and its compounds. These compounds are more numerous than those of all the other elements, and so far as they are constituents of animal and vegetable tissues, they are of more complicated con-

ELEMENTS (*Continued*)—

stitution than most other chemical compounds: in addition to carbon, oxygen, and hydrogen, they not infrequently include nitrogen, sulphur, and phosphorus as constituents. (See Chemical Compounds.)

J. G. F. Druce has described the oxide of what he regards as a new element occurring in commercial manganese sulphate (*Chem. News*, October, 1925, ii., 939).

A list of the chemical elements is given in the following table, and most of their chief compounds are described in this work under their several names. In this table, the atomic weights as tabulated by a committee of the Chemical Society for 1929 are given in order of their atomic numbers, permitting, as is expressed, the inclusion of those elements for which no determinations of atomic weight are available and the inclusion of others not yet discovered in that order (atomic numbers).

Periodic Law—Many of the chemical elements that, to some extent, resemble one another in their properties appear also to exhibit certain numerical relations—for example, lithium and potassium, having the atomic weights of 7 and 39, exhibit an average number 23, which is the atomic weight of sodium. These and other numerical relations and the gradations in the properties of such elements have led up to what is known as the periodic law, the basic idea being that the chemically analogous elements constitute families, the members of which recur after regular intervals when arranged in order of their atomic weights. It may be broadly expressed by the statement that the properties of the elements and their compounds constitute a periodic function of their elemental atomic weights. These functions are noticeable, for example, in their electrical characters, the ductility, malleability, and melting-points of the metals; in their so-called atomic volumes, and the atomic heats of the elements as a periodic function of their atomic weights. The full meaning of these relations is not yet clear, although investigations by means of the mass spectograph appear to have given clarity to some irregularities (see Light (Mass Spectrograph)); but as a working hypothesis the periodic law has proved of much service, and further investigations will probably clear up much that is at present not understandable regarding the constitution of the entities of matter as presented by the various so-called elements and their multitudinous compounds.

(See John A. R. Newlands on *The Periodic Law* (E. and F. N. Spon, London), D. Mendeléeff on "Periodic Law of the Chemical Elements" (Faraday Lecture, Chem. Soc., 1889); J. D. Main Smith (*J.C.S.*, 1927, p. 2209); Chapter XII. of Newth's *Inorganic Chemistry*, 1926 (Longmans, London), which gives a good summary account of this classification; and *Systematic Inorganic Chemistry: from the Standpoint of the Periodic Law*, by Caven and Lander (Blackie and Son, London), 1930.)

Evidence has been adduced to indicate that cohesiveness as well as chemical affinity exerts pressure in its action and plays a part in determining the volumes occupied by molecules.

ELEMENTS *(Continued)*—

LIST OF ELEMENTS AND THEIR SYMBOLS IN ORDER OF THEIR ATOMIC NUMBERS, TOGETHER WITH THEIR ATOMIC WEIGHTS, 1929.

(See *J.C.S.*, 1929, pp. 216-219.)

Atomic Number.	Name.	Symbol.	Atomic Weight.	Mass Numbers of Isotopes in Order of Intensity.
1	Hydrogen	H	1·0078	1
2	Helium	He	$4\cdot002_2$	4
3	Lithium	Li	6·94	7, 6
4	Beryllium	Be	9·02	9
5	Boron	B	10·83	11, 10
6	Carbon	C	$12\cdot003_6$	12
7	Nitrogen	N	14·008	14
8	Oxygen	O	16·0000	16
9	Fluorine	F	19·00	19
10	Neon	Ne	20·18	20, 22, 21
11	Sodium	Na	23·000	23
12	Magnesium	Mg	24·30	24, 25, 26
13	Aluminium	Al	$26\cdot97_0$	27
14	Silicon	Si	$28\cdot0_8$	28, 29, 30
15	Phosphorus	P	$30\cdot98_2$	31
16	Sulphur	S	$32\cdot06_5$	32, 33, 34
17	Chlorine	Cl	35·457	35, 37
18	Argon	A	39·94	40, 36
19	Potassium	K	$39\cdot10_5$	39, 41
20	Calcium	Ca	40·09	40, 44
21	Scandium	Sc	$45\cdot1_5$	45
22	Titanium	Ti	47·90	48
23	Vanadium	V	50·95	51
24	Chromium	Cr	52·04	52
25	Manganese	Mn	54·95	55
26	Iron	Fe	55·84	56, 54
27	Cobalt	Co	58·95	59
28	Nickel	Ni	58·69	58, 60
29	Copper	Cu	63·55	63, 65
30	Zinc	Zn	65·38	64, 66, 68, 67, 65, 70, 69
31	Gallium	Ga	69·72	69, 71
32	Germanium	Ge	72·60	74, 72, 70, 73, 75, 76, 71, 77
33	Arsenic	As	$74\cdot93_4$	75
34	Selenium	Se	79·2	80, 78, 76, 82, 77, 74
35	Bromine	Br	$79\cdot91_5$	79, 81
36	Krypton	Kr	82·9	84, 86, 82, 83, 80, 78
37	Rubidium	Rb	$85\cdot4_3$	85, 87
38	Strontium	Sr	$87\cdot6_3$	88, 86
39	Yttrium	Yt	$88\cdot9_3$	89
40	Zirconium	Zr	91·2	90, 94, 92, (96)
41	Niobium (Columbium)	Nb (Cb)	93·3	
42	Molybdenum	Mo	96·0	
43	Masurium	Ma	—	
44	Ruthenium	Ru	$101\cdot6_5$	
45	Rhodium	Rh	102·9	
46	Palladium	Pd	106·7	
47	Silver	Ag	107·880	107, 109

ELEMENTS *(Continued)*—

Atomic Number.	Name.	Symbol.	Atomic Weight.	Mass Numbers of Isotopes in Order of Intensity.
48	Cadmium	Cd	112·4$_0$	114, 112, 110, 113, 111, 116
49	Indium	In	114·8	115
50	Tin	Sn	118·70	120, 118, 116, 124, 119, 117, 122, 121, 112, 114, 115
51	Antimony	Sb	121·76	121, 123
52	Tellurium	Te	127·5	128, 130, 126
53	Iodine	I	126·93$_2$	127
54	Xenon	Xe	130·2	129, 132, 131, 134, 136, 128, 130, 126, 124
55	Cæsium	Cs	132·8$_1$	133
56	Barium	Ba	137·3$_6$	138
57	Lanthanum	La	138·9$_0$	139
58	Cerium	Ce	140·2	140, 142
59	Praseodymium	Pr	140·9	141
60	Neodymium	Nd	144·2$_5$	142, 144, 146, (145)
61	Illinium	Il	—	
62	Samarium	Sm	150·4$_3$	
63	Europium	Eu	152·0	
64	Gadolinium	Gd	157·0	
65	Terbium	Tb	159·2	
66	Dysprosium	Dy	162·4$_6$	
67	Holmium	Ho	163·5	
68	Erbium	Er	167·6	
69	Thulium	Tm	169·4	
70	Ytterbium	Yb	173·$_0$	
71	Lutecium	Lu	175·$_0$	
72	Hafnium	Hf	178·6	
73	Tantalum	Ta	181·3	
74	Tungsten	W	184·1	
75	Rhenium	Re	—	
76	Osmium	Os	191·$_0$	
77	Iridium	Ir	193·0$_4$	
78	Platinum	Pt	195·2	
79	Gold	Au	197·2$_1$	
80	Mercury	Hg	200·6$_0$	202, 200, 199, 198, 201, 204, 196
81	Thallium	Tl	204·$_3$	
82	Lead	Pb	207·2$_2$	208, 206, 207
83	Bismuth	Bi	209·0$_0$	
84	Polonium	Po	—	
85	—	—	—	
86	Niton (Emanation)	Nt (Em)	222	
87	—	—	—	
88	Radium	Ra	225·9$_5$	
89	Actinium	Ac	—	
90	Thorium	Th	232·15	
91	Protoactinium	Pa	—	
92	Uranium	U	238·1$_5$	

N.B.—In giving the atomic weights, the device of writing the last figure as a subscript has been adopted by the committee in those cases where it may be in error by two or three units, and in the other cases it is to be understood that in their opinion the error probably does not exceed one unit.

In the First Report of the Committee on Atomic Weights of the International Union of Chemistry, giving the results of investigations published since January 1, 1930, a revised table of atomic weights is appended (*J. Amer. Chem. Soc.*, 1931, **53**, 1627-1639). See also Isotopes.

ELEMENTS (*Continued*)—

Richards has pointed out that the compressibilities of the solid elements as determined by him at Harvard University seem to be, like the atomic volumes, periodic functions of the atomic weights.

As to the transmutation of the elements it has been conjectured that the following cases may possibly be factual:

Radium (226 atomic weight) – Helium (4) = Niton (222)
4 Hydrogen (4) = Helium (4)
4 Hydrogen (4) + Oxygen (16) = Neon (20)
Sulphur (32) + 8 Hydrogen (8) = Argon (40)
Selenium (79) + 4 Hydrogen (4) = Krypton (83)

The claim made by Miethe and Stammreich respecting the transmutation of mercury into gold in a mercury lamp (used to produce ultra-violet light) to the extent of giving to glass its well-known ruby tinge has been repudiated. It is true that two other investigators (O. Hönigschmid and E. Zintl) claim to have determined the atomic weight of the gold so produced by potentiometric method as agreeing with that of ordinary gold, but granting that, it was almost certainly contained in the mercury as an impurity. (See Transmutation.)

It is alleged that a modified (isotopic) form of metallic lead can be derived from uranium through ionium and radium as intervening atomic matters, but this calls for definite confirmation. (See Lead.)

The origination of helium from uranium and thorium-bearing minerals; its production from radium and niton said to have been established qualitatively and quantitatively; and, lastly, its synthesis by subjecting hydrogen to the action of the cathode rays and its combination with oxygen to produce neon: all these described circumstances have been regarded by some physicists as demonstrating transmutations of the chemical elements and the common basic nature of ultimate matter.

According to F. W. Aston, who has employed a method of so-called "mass spectra" (that is, spectra obtained on a photographic plate placed *in vacuo*, by deflecting positive rays on to it by passing them first through an electric and then through a magnetic field in such a way that all the rays corresponding to an element of given mass are concentrated in a short line on the plate and those of different masses in other parallel lines), it would appear that boron consists of two; neon, silicon, and chlorine of two or three; bromine of two; krypton of six; and mercury of at least two *isotopes*—that is, entities having substantially the same chemical properties but of slightly different atomic weights. In other words (assuming the absolute purity of the substances employed and other considerations), elements may be simple or complex,

ELEMENTS (*Continued*)—

according as their atoms are all of equal mass or not, and in the latter case they consist of as many isotopes as their atoms have different masses. (See Isotopes and Light (Mass Spectograph).)

Transmutation of one element to another can only be achieved (according to these new views of the constitution of matter) by disruption of the nucleus, and Rutherford is stated to have broken up some of the nuclei by bombardment with swift alpha rays. Some writers on this subject take the problematical old view that all the elements are polymers of hydrogen.

Having regard to recent investigations concerning atomic structure, radio-activity, and the facts above and elsewhere referred to, it may not be correct to regard the chemical elements any longer as chemical ultimates, but merely as more or less stable chemical units or entities—that is, symmetrical arrangements of matter—recognizable by their physical and chemical characteristics and always reproducible under the same set of circumstances, but susceptible of an indefinite number of changes realizable by the application of adequate force.

There still remains an interdependence of matter and force, and just as the manifestations of heat, light, and electricity cannot be made without the employment of chemical entities, so also these chemical entities depend for their characteristics and changes upon force; no matter without force, no force without matter. At the same time, without giving up the conviction of the existence of one primordial matter, the transmutations apparently effected by physicists and the phenomena presented by so-called sub-atomics may not be of the nature supposed but only acts of decomposition upon previously existing compounds or impure substances. For example, granting the production of helium from uranium, it may be derived from a compound of the two substances. Transmutation cannot be accepted until the entire conversion of a substantial quantity of one element into another has been effected, together with the reconversion of the product into the originating substance. (See *Chem. and Ind.*, 1927, **46,** 811; Atoms, Electrons, Force, Matter, Radio-activity, and Transmutation.)

ELEMI—See Gums and Resins.

ELEOPTENES—See Stearoptenes.

"ELINVAR"—An alloy used for the manufacture of the balance springs of watches. Its co-efficient of elasticity does not change with the temperature, so that the control of the spring does not vary with the temperature.

ELUTRIATION—The hydraulic classification of powders—*i.e.*, separation of the lighter from the heavier, or smaller from the larger particles of powders by washing and decantation, using "elutriators"; as, for example, in the preparation of ground barytes for making paint, etc. Various appliances of this kind include those known as the "Schone," "Boswell's," and "Lowry's." (See *C.T.J.*, 1924, **74,** 403.)

EMANATIONS—Waves or electronic or gaseous products radiated or evolved from substances. (See Elements, Helium, Radio-activity, Radiation, and Radium.)

EMBOLITE—A mineral chloro-bromide of silver (of crystal system, No. 1, and sp. gr. 5·79) found in Arizona, Colorado, New Mexico, and Chile, having the composition variously given as $Ag_5Cl_3Br_2$ and Ag(ClBr).

EMERALD—A gem found in mineral form in Colombia, Venezuela, etc., being a double silicate of aluminium and glucinum, or green variety of *beryl,* containing some chromium sesquioxide (Cr_2O_3).

EMERALD GREEN—See Copper Compounds.

EMERY—See Abrasives and Aluminium (Corundum).

EMETINE—See Ipecacuanha.

EMODIN ($C_{40}H_{30}O_{13}$)—A crystalline substance of orange colour, m.p. 250° C., found as a constituent of rhubarb root and in the bark of *Rhamnus Purshiana, cascara sagrada,* chrysarobin, etc.; soluble in alcohol.

EMULSIN (Synaptase)—An enzyme or a mixture of enzymes occurring in bitter almonds, capable of hydrolyzing most of the natural glucosides. (See Amygdalin, Enzymes, and Glucosides.)

EMULSIONS—Mechanical admixtures of fluids that will not naturally mix together, such as oil and water; apt to separate more or less into layers on standing, and which may sometimes be broken by churning, freezing, heating, electric currents, addition of other chemicals, etc.

Some are prepared by the use of gum, resin, invert sugar, or saponin in a state of solution, having the property of holding in suspension the oily particles of other liquids shaken up therewith; others are variously prepared with milk, the yolk of eggs, soaps, or mucilage. Emulsions have been described as "model suspension colloids," and again as "heterogeneous systems" in which a liquid is dispersed as globules or droplets in some other liquid with which it is only partially or not at all miscible.

An emulsion, however, is better described as a system of two liquid phases, one continuous in character and the other discontinuous or disperse, and if the disperse phase is made up of very minute particles of, say, one-millionth to one-ten-thousandth of a millimetre in diameter, the system is termed an emulsoid.

According to T. Smith (*J. Inst. Chem.,* 1930, Part II., 116) there is an interfacial film between the bulk phases of an emulsion varying in properties, and that lowering of surface tension favours drop formation and therefore emulsification. In cases of high interfacial tension the liquids are of low miscibility, while if low they are readily miscible. Bechhold and Silbereisen conclude from their reported experiments that a low interfacial tension has practically no significance in determining stability of emulsions and that viscosity does not play an essential part (*B.C.A.,* 1930, A, 32). In Wellman and Tartar's opinion respecting water-soap-oil emulsions, low interfacial tension aids dispersion, but that must be accompanied by a substance capable of forming per-

EMULSIONS (*Continued*)—

manent films round the droplets to make the emulsion stable (*B.C.A.*, 1930, A, 413). They are, for the most part, milky in appearance, but there are other emulsions which, though quite translucent and uniform in character, are not regarded as true solutions.

Emulsoids is the term given to emulsions in respect of which the dispersity is high and may be prepared directly by adding a suitable continuous phase to a gel and then warming the mixture, a familiar instance being the way the carpenter prepares his glue.

An emulsion of oil in water (such as milk) is produced if the emulsifying agent is a colloid soluble in water or more easily wetted by water than oil, and an emulsion of water in oil (such as butter) is obtained when the emulsifying agent is an oil-soluble colloid or is more easily wetted by oil than by water.

Reference to the emulsification of butter, milk-powder and water into cream is made under the heading of Milk. In this churning process it is stated that the globules of fat are so broken up as to become reduced to half the size of those naturally occurring in ordinary milk.

Emulsions of various paraffin hydrocarbons in water with casein as the emulsifying agent are described, as of the oil-in-water type up to *d* 0·828 and of the water-in-oil type above 0·860. (W. Seifriz, *J.C.S. Abs.*, 1925, ii., 663.)

Coalescence is caused by molecular attraction resulting from proximity of surfaces, and the more stable emulsions are those having solid films of emulsifier around the globules of minimum thickness, while the best emulsifiers are those having a crystallizing force greater than the surface tension forces. The ageing of jellies and precipitates is attributed to surface migration and not to coalescence, and the elasticity of jellies results from restriction to molecular movement in some directions. (See A. V. Slater (*Chem. and Ind.*, Jan. 4, 1926).)

Fine and very stable emulsions are formed when animal or vegetable oils are added to a solution of sodium silicate (2 per 1,000), the oil drops being so small that many of them exhibit the Brownian movement. In this case the fatty acids of the oil combine with the sodium to form a soap, thus liberating silicic acid in colloidal form, which acts as a protecting colloid. A new emulsifying agent, trihydroxy-ethylamine, is a wax-like substance soluble in water and hydrocarbons, which can be melted without decomposing. (See *C.T.J.*, 1930, **87,** 512.)

The de-emulsification of petroleum deposits or watery oil can be effected electrically by passage of a high-tension alternating current between electrodes. Other emulsions may be broken down by the addition of or shaking up with various electrolytes such as hydrochloric acid, alum, or ferric chloride, and in some cases by centrifugal treatment.

References: Some industrial applications of emulsifying agents, by S. R. Trotman (*C.T.J.*, 1928, **83,** 77, 105, and 225); W. Clayton (*Ind. Chem.*, 1925, i., 223, and *J.S.C.I.*, 1926, **45,** 288 T); R. C. Smith (*J.S.C.I.*, 1927, **46,** 345 T); H. M. Langton (*Ind. Chem.*, 1927, iii., 457); G. B. Chilvers (*C.T.J.*, 1928, **83,** 163); W. E. Gibbs (*Chem. and Ind.*, 1929, **48,** 135); E. L. Smith (with others) (*B.C.A.*, 1931, B, 223);

EMULSIONS (*Continued*)—

"The Preparation of Emulsions," by W. Clayton (*Chem. and Ind.*, 1932, **51**, 129); Clayton's book on *The Theory of Emulsions and their Technical Treatment* (J. and A. Churchill); Bitumen, Colloid Chemistry, Gelatin, Lecithin, and Wetters.

EMULSOIDS—See Emulsions and Colloid Chemistry.

ENAMEL PAINTS—See Paints, Lacquers, and Varnishes.

ENAMELLED IRON—Iron plates are enamelled by coating them (after cleaning) with alkaline silicates containing borates, this mixture being more readily fusible than glass, and then firing them. The enamels can be coloured by the incorporation of metallic oxides, etc., or rendered opaque with stannic oxide, etc. (See Enamels.)

ENAMELS—Ordinary enamels have as their chief constituents, quartz, felspar, clay, soda, and borax, powdered glass and fluorspar being sometimes added, and saltpetre or potash being used as fluxes. In other words, they are fusible glasses rendered opaque by dissemination throughout the mass of a vitreous substance, such as tin dioxide, infusible at the temperature at which they are made. Up to about 900° C. the tin dioxide exists in a state of suspension in the enamel, but if that temperature be exceeded, real solution takes place and the opacity is diminished. Titanic oxide, zirconia, antimony tetroxide, sodium metantimonate ($NaSbO_3$), and other vitreous substances can be employed in place of the stannic oxide. The opacity is due to the difference in refractive index, and is obtained in other cases by the use of arsenious oxide, calcium phosphate, cryolite, etc. Platinum and iridium oxide are sometimes used to produce greys in enamels, and a great variety of other substances (mainly metallic oxides) according to the desired tint and other characteristics, the choice being limited to such materials as will withstand firing.

In making acid-resisting enamels, alkali-earth silicates are mainly used as distinct from the ordinary enamels containing a high percentage of borates, the chief constituents being silica, alumina, lime, and magnesia. Good acid-resisting enamels are only attacked by hydrofluoric, acetic, and formic acids. A temperature as high as 900° C. is sometimes used in their manufacture, and high mechanical strength has to be attained.

One kind of enamel used for glazing cast-iron articles, such as saucepans, consists of powdered flint ground together with calcined borax, fire-clay, and a little felspar, made into a paste and applied to the surfaces, which are then dusted over with a glaze mixture composed of felspar, soda-ash, borax, and a little oxide of tin, after which they are dried and fired at a red heat.

Jewellery enamels are prepared from silica, lead oxide, some proportion of sodium dioxide with varying proportions of other oxides, and in certain cases boric acid.

The "porcelain" enamelling of iron castings such as baths is described by W. Thomason (*Ind. Chem.*, 1925, i., 273); the enamelling of steel (*C.T.J.*, 1925, **77**, 211); and "Antimony as a Constituent

ENAMELS (*Continued*)—
of Enamels," by L. R. Mernagh (*Chem. and Ind.*, 1925, **44,** 815); "Mechanics of Enamel Adherence," by various authors (*B.C.A.*, 1932, **51,** 23). See also *Enamels—their Manufacture and Applications to Iron and Steelware*, by L. R. Mernagh (C. Griffin and Co., Ltd., London); Glass, Glazes, and Porcelain. For other classes of enamels see Cellulose, Lacquers, Nitrocellulose, Paints, Pyroxylin, and Varnishes.

ENARGITE—A mineral double sulphide of copper and arsenic (6CuS, As_2S_2), of crystal system, No. 4, and sp. gr. 4·3 to 4·5, found in parts of the U.S.A. and elsewhere.

ENDOSMOSIS—See Dialysis and Osmosis.

ENDOTHERMIC COMPOUNDS—See Heat.

ENERGY—The power of overcoming resistance or doing work, the sun being the only source of great importance to mankind.

Chemical energy is manifested by chemical changes, and the critical increment of energy characteristic of a specific reaction is that which must be supplied to bring each molecule from its initial to its reactive stage.

A gas expanding in a cylinder takes in heat and gives out work, and if it is a perfect gas, as hydrogen nearly is, the heat taken out is exactly equal to the work given out. According to J. A. Fleming, "with the best modern boilers, engines, and dynamos, one horse-power for one hour can be generated in the form of electric energy by the combustion of 1 lb. of coal" (*The Times*, September 28, 1925). E. C. Baly has suggested that the high-energy character of foods may suffer deterioration by cold storage, and that living tissues possess an energy over and above that of their dead forms and constituents viewed as ordinary chemical substances, and in the same connection it may be borne in mind that many chemical substances exhibit higher energy in their nascent state, and can also be activated by the action of ultra-violet rays. R. A. Millikan is not alone in the view that the supposition of an energy evolution through the disintegration of the common elements is a "foolish bugaboo," inasmuch that it would require the expenditure of a greater energy to break them up than any releasable therefrom.

Available energy was the subject of the Messel Memorial Lecture in 1928 by R. A. Millikan (*J.S.C.I.*, 1928, **47,** 288 T). See also report of an address by A. Eddington on "Sub-atomic Energy" (*The Times*, June 24, 1930); Force, Mass, Matter, Nascent, Quantum Theory, and Vitamins.

ENFLEURAGE—See Perfumes.

ENGINEERING (CHEMICAL)—See Chemical Engineering.

ENSILAGE—A process (insufficiently used) for preserving green fodder, such as oats, tares, grass, and maize, for cattle. The pit in which the fodder is stored and pressed down is termed the "silo," and the product is named "silage," the object aimed at being the exclusion of air as far as practicable, thus permitting of a limited fermentation, during which

ENSILAGE (*Continued*)—

much of the protein is transformed into amides (amino-acids), although the mass still contains considerable amounts of cellulose, lignin, and humic substances. The "tower" form of silos are superior to the "clamp" form. Acetic acid is produced during the fermentation, and this acts as a preservative. Lactic acid is also produced when maize and *Sorghum vulgare* are employed (see Sellschop and Salmon, *B.C.A.*, 1929, B, 68).

The pigment of silage is stated to be the magnesium-free derivative of chlorophyll, which is soluble in hot alcohol and acetic acid, its production being probably due to the action of carbon dioxide and organic acids developed during the fermentation.

As regards the composition of silage, values have been given as follows: water, 64·7 to 87·5 per cent.; fat, 0·2 to 3·3 per cent.; crude protein, 1·4 to 6·6 per cent.; true protein, 0·86 to 3·71 per cent.; carbohydrate, 6·2 to 17 per cent.; fibre 1·8 to 11·5 per cent.; and ash, 1·7 to 3·5 per cent., as prepared from twenty different materials. (See *J.C.S. Abs.*, 1925, cxxviii., I., 1523; "Losses in the Tower Silo," by H. E. Woodman and A. Amos (*J. Agric. Soc.*, 1926, **16**, 539); H. E. Woodman and F. Hanley (*B.C.A.*, 1926, B, 296); W. L. Gaines and W. B. Nevens (*B.C.A.*, 1926, B, 296); and T. C. Sutton respecting the fodder value of dried grass and the "Peterson" system of drying (*Ind. Chem.*, 1928, iv., 401).

ENTROPY—Measure of the unavailability of a system's thermal change for conversion into mechanical work (Oxford Concise Dictionary). "The entropy change in a reaction is the link between the free energy change and the determinable heat effect," and "if we know the entropy changes and the heat effects of reactions we can find at once the free energy changes" (J. A. V. Butler, *Chem. and Ind.*, 1929, **48**, 599).

ENZYMES—A class of non-organized, colloidal, nitrogenous substances produced by and associated with certain living animal and vegetable tissues, capable of initiating changes in many chemical substances by way of fermentation, hydrolysis, and oxidation, quite disproportionate to the small amounts employed. They are characterized by the great amount of surface they present, and are in a finer state of division than most other catalytic agents, a state of affairs which naturally promotes their activity, the two phenomena of enzyme and catalytic action being of one class.

The action of enzymes is not invariably of a decomposing character, as there is evidence of their ability to serve as synthetic agents in certain cases under appropriate circumstances.

They also exhibit individuality of character, as, for example, in respect of sugars nearly allied, by decomposing some and not others. (See Yeasts.)

Ptyalin, the active ferment of saliva, converts the starch of food into sugar, and the alcoholic fermentation of sugar is due to the enzyme named zymase, as produced by yeast cells. (See Fermentation and Invertase.) For the most part enzymes seem to act by way of hydrolysis, one such change, for example, being the conversion of cane-sugar

ENZYMES (*Continued*)—

into glucose and fructose by invertase, brought about by the assimilation of water—

$$C_{12}H_{22}O_{11} + H_2O = C_6H_{12}O_6 + C_6H_{12}O_6.$$

Another such change is the hydrolysis of starch by means of amylopsin or pancreatic diastase into maltose and dextrin; while by a further change, these two saccharoid bodies are converted into alcohol ($C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$). Starch is similarly converted by diastase into maltose ($C_{12}H_{22}O_{11},H_2O$) (malt sugar), and malto-dextrins are converted by the enzyme diastase contained in germinated barley. (See Beer.)

Emulsin probably contains several distinct enzymes.

The digestive enzymes comprise many hydrolytic agents capable of replacing the $—NH_2$ group by the $—OH$ group, as in the case of urea.

Trypsin, one of the pancreatic enzymes, is most active in the presence of alkalies, and decomposes many albuminous bodies down to the stage of polypeptides, whilst papain (papayotin), which occurs in the papaw-tree (*Carica papaya* L.), is a similar enzyme of vegetable origin. Pepsin, on the other hand, acts only in acid solutions, and while it does not hydrolyse any known polypeptide, it converts albumins into a number of derived compounds—viz., the so-called anti- and hemi-albumoses—but does not proceed so far in its action as to produce simple amino-acids.

It has been shown, however, that pancreatin and trypsin can carry the stage of hydrolysis of albumoses farther, thus converting anti-albumose into peptone and hemi-albumose into leucine, tyrosine, aspartic acid, and glutamic acid, these last-named substances being members of the amino-acid group. (See Amino-acids and Proteins.)

Hydrolytic enzymes exhibit their maximum activity at about 37° C., and give best results in faintly acid solutions.

The class of enzymes styled *desamidases* are stated to be capable of splitting up the amino-acids into ammonia and hydroxy acids.

Catalase is a common name for a group of enzymes (one of which can be prepared from germinated beans) which have the power of catalysing hydrogen peroxide, amongst other properties.

By modifying the process of mashing, the amylase in rye and wheat is stated to be sufficient to saccharify the whole starch present in the corns (Staiger, *B.C.A.*, 1928, B, 766).

Lipase (one type of which is contained in castor seeds)—an enzyme associated with trypsin—has the power of breaking up fats into glycerol and fatty acids. It is used industrially, and is supposed to be concerned in causing rancidity.

Urease is described as a crystalline enzyme extracted from "Arlco" jack-bean meal by dilute acetone. (See J. P. Sumner, *Analyst,* 1926, **51,** 637.)

There are certain enzymes occurring in all parts of plants and animals named *oxidases* (*oxydases*), or *peroxidases,* which are concerned in acts of oxidation, as distinct from hydrolysis—for example, in the process of respiration.

ENZYMES (*Continued*)—

Another enzyme, styled aldehydase, said to be contained in the liver, lung, and spleen, is credited with the capability of converting aldehydes into the corresponding acids.

The *coagulase* class of enzymes can institute changes in various liquids, resulting in the formation of insoluble substances; thus, rennet (chymase) forms curd in milk; thrombose (thrombin) is concerned in the coagulation of blood; and pectase in the production of insoluble pectic acids from the pectin substance of plants.

The particular enzymes associated with bacterial life are necessarily many in number, and must vary in their chemical actions, not merely with the kind of bacteria, but more particularly with the media in which they are allowed to develop, so that their entire range of action must be enormous and correspondingly varied in character.

In the action of enzymes as catalysts, the rate is proportional to their strength, although the total changes which they institute are independent of the amount, given sufficient time. Their activity is wholly destroyed when heated to 100° C., while rennet, thrombose, pepsin, and diastase are inactivated at 45° C. As to the mechanism of enzyme action, it is generally held that adsorption compounds are formed between the enzyme and the substrate—that is, the substance which is decomposed—and that it is these compounds which react with water; but the whole subject calls for much further investigation.

Enzymes are very sensitive to small changes of environment, and there is physiological evidence that their action can be stopped or set free by the living cells, and when separated from these they are more or less unstable; moreover, freedom from associated bodies has a marked effect on their specificity. Their action is often assisted or promoted by associated substances styled co-enzymes or activators, and, on the other hand, it is often interfered with or arrested by other substances, classed as paralyzers or poisons (like sulphur), the latter behaving, in this sense, as antiseptics do in respect of bacterial processes of decomposition. So far, no enzyme has been isolated, and it is highly probable that there is no such thing as an enzyme, but that which is really dealt with is "a big colloid surface, one part of which contains a certain grouping which, under the proper physical conditions, is able to act as a catalyst"—that is to say, actually participate in the chemical changes that occur, although it is not possible to completely separate the chemically active group from the protective colloid without loss of activity. In this way they may behave in much the same way as the vitamins in respect of their activity. See R. Willstätter's Faraday lecture on Problems and Methods in Enzyme Research (*J.C.S.*, 1927, pp. 1359-1381); E. F. Armstrong and T. P. Hilditch (*B.C.A.*, 1929, A, 1488), and a summary of their conclusions respecting the essential parts of a natural enzyme *per se* (*Chem. and Ind.*, 1930, **49,** 23); Manskaja and Schilina on "Enzyme Content of Trees during the Winter Rest Period" (*B.C.A.*, 1932, A, 99); K. G. Falk's *Chemistry of Enzyme Actions* (Chem. Catalog. Co., N.Y.); Bayliss's *Nature of Enzyme Action* (Longmans, Green and Co.); J. B. S. Haldane's

ENZYMES (*Continued*)—
Enzymes (Longmans); F. F. Nord's *Enzyme Action and Associated Cell Phenomena* (Baillière, Tindall and Cox); also Aspergillus, Catalysis, Cytase, Diastase, Emulsin, Maltase, Oxidases, Rennet, Starch, Vitamins, and Zymogens.

EOSIN ($C_{20}H_8Br_4O_5$)—A red, crystalline dye, soluble in alcohol and acetic acid, prepared by the bromination of fluorescein; it is used for dyeing silk, cotton, and wool; also for making a red ink and vermilion substitute. The potassium salt of tetrabromofluoresceïn, $C_{20}H_6Br_4O_5K_2$, is also *commercially* known as *eosin,* and used for the same purposes.

EPHEDRINE ($C_{10}H_{15}NO$)—A colourless, crystalline alkaloid, soluble in water, alcohol, and ether, extracted from the leaves of several species of *Ephedra* including *Ephedra helvetica*, although *Ephedra sinica* (Staff) is stated to be the most reliable. It is accompanied by its isomer *pseudo-ephedrine*, the total alkaloids amounting to about 1 per cent. in the herb marketed as MaHuang (China). It acts like adrenaline in raising the blood pressure and in relaxing contracted bronchi, and has a reputed value in the treatment of asthma, hay fever, and as a diuretic. It can be administered by the mouth, the hydrochloride being the salt most frequently prescribed. Some particulars respecting the amounts of alkaloids in various species have been given by Read and Feng (*B.C.A.*, 1929, B, 188) and Ghosh and Krishna (*J.S.C.I.*, 1929, **48,** 67 T, and *B.C.A.*, 1931, B, 610), and its synthesis has been recently effected, its composition being given as identical with 1-phenyl-2 methyl-amino-propanol (*Chem. and Ind.*, 1929, **48,** 579). (See also T. and H. Smith (*Pharm. J.*, 1929, **123,** 606); S. Kanao (*B.C.A.*, 1930, A, 352); and a review and bibliography by H. Ernde (*Arch. Pharm.*, 1930, **268,** 83-103).)

"EPHOS"—A basic phosphate made from an Egyptian source, containing from 60 to 65 per cent. of tricalcium phosphate, of which 85 to 95 per cent. is soluble in 0·2 per cent. solution of citric acid.

"EPONITE"—A char in the nature of a vegetable soot, containing about 82 per cent. of carbon, the decolourizing efficiency of which is increased, according to C. F. Bardos, by addition of 30 to 50 per cent. of charred sawdust. (See "Karbos.")

"EPSOMITE"—See Magnesium (Sulphate).

"EPSOM SALTS"—Trade name for magnesium sulphate.

EQUATIONS—See Chemical Interactions.

EQUILIBRIUM—A balance of forces as experienced in reversible chemical reactions, and illustrated by melting-points at which temperatures, solids, and liquids co-exist (in equilibrium). (See Chemical interactions.)

EQUIVALENTS—See Chemical Compounds.

ERBIUM (Er) **and its Compounds**—Atomic weight, 167·6; sp. gr., about 4·77. A rare element belonging to the so-called yttrium group, and occurring in nature in the minerals *gadolinite, yttrotantalite, euxenite,* etc., together with the earth *yttria.* Its yellow oxide erbia (Er_2O_3) is obtained by heating the nitrate or precipitated hydroxide; it can be also prepared by heating the oxalate at 575° to 845° C. Its salts, including

ERBIUM (*Continued*)—

the chloride ($ErCl_3$), nitrate ($Er(NO_3)_3 5H_2O$), bromide ($ErBr_3,9H_2O$), chlorate ($Er(ClO_3)_3,8H_2O$), bromate ($Er(BrO_3)_3$), and sulphate ($Er_2(SO_4)_3,8H_2O$), etc., are crystalline in character, of a rosy tint, and are soluble in water.

EREMACAUSIS—Slow decomposition or consumption by oxidation and other changes as evidenced in nature by the decay of timber, the heating of grain or grass, the decomposition of vegetable matter generally, etc. Low forms of life have much to do with the initiation of the concerned processes, which are retarded by perfect dryness and by a temperature below freezing-point. (See Wood (Dry-rot).)

ERG—See Force.

ERGOSTEROL as obtained from yeast and ergot of rye is represented as having the composition $C_{27}H_{42}O$, m.p. 160° to 161° C., and present therein to about 0·15 per cent. It is stated to give an acetate of m.p. 172° to 173° C., which upon reduction and hydrolysis yields so-called ergostanol ($C_{27}H_{48}O$), and this by further reduction yields a hydrocarbon ($C_{27}H_{48}$) of m.p. 72° to 73° C. (See Morton and others, *J.C.S.*. 1927, p. 2000; Reindal, Walter, and Ranch, *B.C.A.*, 1927, A, 241; Rosenheim and Webster, *Lancet*, 1927, **213,** 622; I. S. MacLean (*Chem. and Ind.*, 1929, **48,** 295); F. Reindal (*B.C.A.*, 1929, A, 61); Bills and Honeywell (*B.C.A.*, 1929, A, 104); O. Rosenheim and T. A. Webster (*Analyst*, 1927, **52,** 652); T. A. Webster and R. B. Bourdillon (*Analyst*, 1929, **54,** 52); Bills and Cox (*B.C.A.*, 1930, A, 84); de Boe (*B.C.A.*, 1931, A, 1412); Hart and Heyl (*J. Amer. Chem. Soc.*, 1930, **52,** 2013).) These last-named investigators obtained a yield of 0·13 per cent. crude ergosterol from a sample of Spanish ergot, and found it to contain ergosterol of m.p. 163° to 164·5° C., fungisterol of m.p. 144° to 146° C., and a third sterol $C_{27}H_{46}O$ of m.p. 120° to 125° C. Certain irradiation products of ergosterol have been studied by Windauss and associates (*B.C.A.*, 1930, A, 1577), also by Moore and De Vries (*J. Amer. Chem. Soc.*, 1931, **53,** 2676); and its purification by R. K. Callow (*Biochem. J.*, 1931, **25,** 79).

Ergosterol is alleged to exhibit a surprising stability when present in minute amount in ordinary cholesterol from all animal sources in view of its own labile character. It is regarded as the parent substance of vitamin D, and according to King, Rosenheim, and Webster (*Biochem. J.*, vol. 23, no. 2, p. 167) the ergosterol content of cholesterol isolated from the brain of a mummy after 1,400 years is yet of the same order as that prepared from fresh brain-matter. It gives a blue colour reaction with chloral hydrate and with trichloracetic acid, enabling its detection in presence of other naturally occurring sterols (O. Rosenheim, *Biochem. J.*, 1929, vol. 23, no. 1, p. 47); see also Sterols, Vitamins, Yeast.

ERGOT OF RYE—A fungoid growth (*Claviceps purpurea*) to which the seed of the common rye is liable, containing an active principle named ergotine—a yellow crystalline alkaloid soluble in alcohol and ether, possessing narcotic properties and m.p. 255° to 260° C. It is used in

ERGOT OF RYE (*Continued*)—

midwifery, etc., and is collected in Russia, Austria, Germany, and Spain.

According to one account, the chief active principles of ergot are—

(1) An amorphous alkaloid named ergotoxine ($C_{35}H_{41}O_6N_5$), ergotinine being described as its anhydride.

(2) Histamine ($C_5H_9N_3$).

(3) Tyramine ($C_8H_{11}ON$).

(4) Acetylcholine ($C_7H_{17}O_3N$).

Ergosterol is also stated to be a constituent of ergot.

The ergots of diss (*Ampelodesmos tenax*) and of oats contain the same compounds as that of rye in different proportions, that of diss containing per kilo 0·1 grm. of crude ergotinine and that of oats per kilo 0·18. The last named may, it is stated, be used as a complete substitute for ergot of rye.

From another investigation it appears that a hitherto unknown amine of high molecular weight having the characteristic therapeutic action of ergot has been isolated in a yield of 0·1 to 2·0 grms. per kilogramme. This amine, named ergotamine, is described as a crystalline body of formula $C_{33}H_{35}O_5N_5$, which effloresces upon exposure to the air and soon decomposes.

Ergotinine would appear to be interchangeable with ergotoxine. The formulæ $C_{35}H_{39}O_5N_5$ and $C_{35}H_{41}O_6N_5$ have been suggested for the two first-named bodies (Barger and Carr), and $C_{33}H_{35}O_5N_5$ for ergotamine (Spiro and Stall). The chemical composition of ergot oil is described by W. F. Baughman and G. S. Jamieson (*Analyst*, 1928, **53**, 387), and the alkaloids of ergot are dealt with in recent papers by Smith and Timmis (*J.C.S.*, 1930, p. 1390, and 1931, p. 1888). See also G. Barger on "Ergot and Ergotism" (*Chem. and Ind.*, 1931, **50**, 178).

"ERINOID"—A condensation product or synthetic resin having a casein base.

ERLENMEYER FLASK—See Flasks.

"ERNOLITH"—A plastic material prepared from waste yeast by treatment with formaldehyde, grinding the product with tar, sulphur, or pigments, and moulding under pressure of 3,000 lbs. at above 90° C.

ERUCIC ACID ($C_{22}H_{42}O_2$)—An unsaturated acid of the $C_nH_{2n-2}O_2$ series, contained in rape-seed oil, and obtainable from arachidic acid; iv., 74·3; m.p. 33·5° C. (See Eicosanoic Acid.)

ERYTHRITE (**Erythrine, Cobalt Bloom**)—See Cobalt.

ERYTHRITOL (**Butane-tetrol**)—An alcohol which is found in various lichens in the free state or combined with orsellinic acid; a crystalline substance soluble in alcohol and insoluble in ether; m.p. 112° C.

ERYTHROSIN—A dye, allied in constitution to eosin.

ESERINE—See Calabar Bean.

ESPARTO GRASS (**Halva, Alfa, Alva**)—A strong tufty wild grass (*Stipa tenacissima* or *Lygeum spartum*, very similar to *Stipa tenacissima* or alfalfa), which grows abundantly in Tripoli, Spain, and Algeria, and

ESPARTO GRASS (*Continued*)—
is largely used in the manufacture of cordage, baskets, sandals, mats, ropes, paper, and by upholsterers as a stuffing material. It contains about 90 per cent. of a cellulosic body. It is boiled with caustic soda or lime water to dissolve the fleshy parts, then bleached. A wax used in soap-making, amounting to 3½ per cent., is obtained as a by-product. The trade is large, amounting to more than 200,000 tons per annum. (See C. de Neyman (*B.C.A.*, 1931, B, 713).)

ESSENCES—Another name for essential oils; also applied to compounds, such as alcoholic and other preparations of plant constituents and fruit juices, etc. (See Perfumes.)

ESSENTIAL OILS are the volatile oils or essences formed naturally in various trees and plants, such as oil of turpentine (pine-trees), eucalyptus oil (eucalyptus-trees), camphor oil (camphor-trees), etc.

Many of them, including those already named, are in the main hydrocarbons, and are characterized by their various constituent terpenes which are isomeric bodies having for the most part the general chemical formula $C_{10}H_{16}$. Others contain, in addition, oxidized substances of the nature of alcohols or ketones. Pine and fir trees are widely distributed in nature, but the turpentine oil which they yield is by no means uniform in constitution. Russian, American, German, Venetian, Swiss, Swedish, French, and Indian oils all differ in the nature or proportions of the various terpenes contained in them and some other constituents.

The essential oils have characteristic odours and are all inflammable, insoluble in water, but soluble in alcohol and in ether. Many are more or less susceptible to oxidation when exposed to the air or oxygen gas, thus forming oxidized products and at the same time always giving rise in the presence of water (if they contain any terpenes) to the formation of hydrogen dioxide; ozone is not produced (Kingzett).

"Close structural relationships are often observed to exist between the individual components of a particular essential oil" and "striking parallels may be discerned between groups of substances occurring in two or more oils from related species." (See J. Reid's paper on "Some Biogenetic Relationships in the Menthone Series" (*Chem. and Ind.*, 1929, **48**, 786).)

The following is a list of some of the better-known essential oils, showing the nature of their chief constituents:

American turpentine oil,	containing	dextro-pinene ($C_{10}H_{16}$, a terpene).
French ,, ,,	,,	lævo-pinene ($C_{10}H_{16}$, a terpene).
Russian ,, ,,	,,	sylvestrene ($C_{10}H_{16}$, a terpene).
Camphor oil	,,	camphor ($C_{10}H_{16}O$, a ketone together with a terpene).
Eucalyptus oils	,,	cineol (an ether), eucalyptene and phellandrene (terpenes).
Orange oil	,,	hesperidene and limonene (terpenes).
Lemon oil	,,	limonene (a terpene) and citral (an aldehyde).
Thyme oil	,,	thymene (a terpene) and thymol ($C_{10}H_{14}O$, a phenol).
Sandalwood oil	,,	santene (a terpene).

ESSENTIAL OILS (*Continued*)—

Citronella oil	containing	geraniol (an alcohol).
Peppermint oils	,,	menthol (an alcohol).
Spearmint oil	,,	carvone (a ketone).
Wintergreen oil	,,	methyl salicylate.
Cinnamon oil	,,	cinnamic aldehyde.

In the *umbelliferæ*, the essential oil is most abundant in the seeds; in the *aurantiaceæ*, both fruits and flowers yield oil; the *rosaceæ* contain oil only in the petals; while the *myrtaceæ* and the *labiatæ* yield most from the leaves. As further illustrating the immense variety of character of essential oils, it may be mentioned that there are more than 200 species of the eucalyptus, and all the oils vary in character. The better-known ones are the *amygdalina, globulus, oleosa, odorata, rostrata, dumosa,* and *citriodora* oils. These oils are all produced by distillation from the parts of the trees containing them, whilst turpentine oils are produced as described elsewhere.

Many of the essential or ethereal oils are used by soap-makers and perfumers for flavouring purposes, and in the preparation of cordials, etc. Most of them are described under their individual names, while the extraction of them is further referred to under the heading of Perfumes. (See article on "The Extraction of Essential Oils from Plants and Flowers" (*Ind. Chem.*, 1926, ii., 393); J. Challenger (*Ibid.*, 1928, iv., 315); F. Singleton (*Chem. and Ind.*, 1931, **50**, 839); E. J. Parry's *Cyclopædia of Perfumery* (J. and A. Churchill); *The Essential Oils,* by H. Finnemore (Ernest Benn, Ltd); also Balsams, Eucalyptus Oils, Hydrocarbons, Perfumes, Terpenes, and Turpentine.)

ESTER GUMS—See Gums and Resins.

ESTER NUMBER—See Fats.

ESTERIFICATION—The process of formation of esters. (See Esters.)

ESTERS (Ethers)—Many alcohols react with mineral and organic acids, like metallic hydroxides, and form what are termed alkyl (ethereal) salts or *esters;* for example, ethyl alcohol and acetic acid by interaction give ethyl acetate and water ($C_2H_5OH + CH_3COOH = CH_3.COO.C_2H_5 + H_2O$), the replaceable hydrogen atoms of the carboxyl group (COOH) being exchanged for alkyl radicals, and the process is known as esterification.

The normal esters of the fatty acids are more or less volatile, neutral liquids which are readily hydrolysed when heated with water and alkalies or acids, back again into the corresponding alcohols and acids.

Nearly quantitative yields of various esters, including stearic, succinic, benzoic, maleic, and cinnamic acids, are obtained by heating the acids with a slight excess of alcohol, a quantity of sulphuric acid equivalent to the alcohol used, and anhydrous aluminium sulphate at 100° C. (Kotake and Fujita, *B.C.A.*, 1928, A, 990).

Methyl Acetate ($CH_3.COO.CH_3$)—A colourless, fragrant, volatile liquid of sp. gr. 0·9244 and b.p. 54° C.; soluble in water, alcohol, and ether; made by heating methyl alcohol and acetic acid in presence of sulphuric acid and distillation. It is used as a solvent, also in per-

ESTERS (*Continued*)—

fumery and making extracts, and is resolved by hydrolysis into methyl alcohol and acetic acid—$CH_3.COO.CH_3 + H_2O = CH_3COOH + CH_3OH$.

Methyl Benzoate (Essence Niobe) $C_6H_5.COO.CH_3$—A colourless liquid of sp. gr. 1·1026 and b.p. 199° C., soluble in alcohol and ether and slightly soluble in water. It occurs naturally in the oils of tuberose and ylang-ylang, and is used in perfumery. It is prepared by heating benzoic acid and methyl alcohol in presence of strong sulphuric acid, followed by distillation.

Ethyl Acetate ($CH_3.COO.C_2H_5$) is a colourless, fragrant, inflammable liquid of sp. gr. 0·9003 and b.p. 77·15° C., soluble in water, alcohol, and ether. It freezes at $-83·6°$ C., and is prepared by heating a mixture of ethyl alcohol, acetic acid, and sulphuric acid. Dissolved in alcohol it constitutes the so-called "essence of pears," and is extensively used in perfumery, in medicine, also for fumigating wheat, flavouring, and as a solvent of nitro-cellulose and soluble forms of cellulose acetate, etc.

Ethyl Benzoate ($C_6H_5.COO.C_2H_5$)—A colourless, aromatic liquid of sp. gr. 1·0503 and b.p. 213° C., soluble in alcohol and ether; prepared by heating ethyl alcohol and benzoic acid in presence of sulphuric acid; used in perfumery and for flavouring ("Essence of Niobe").

Ethyl Butyrate ($CH_3.(CH_2)_2.COO.C_2H_5$)—A colourless, volatile liquid of sp. gr. 0·8788 and b.p. 120° C., soluble in alcohol and ether, constituting the so-called "essence of pineapples," and largely used for flavouring.

Ethyl Caprylate ($CH_3(CH_2)_6.COO.C_2H_5$) of sp. gr. 0·87 and b.p. 208° C.; used in making wine bouquet and "cognac essence."

Ethyl Cinnamate ($C_6H_5.CH:CH.COO.C_2H_5$)—A pleasant-smelling oily body (sp. gr. 1·0546 and b.p. 271° C.), soluble in alcohol and ether, made from ethyl alcohol and cinnamic acid in presence of sulphuric acid, and used in perfumery.

Ethyl Formate ($C_2H_5.HCO_2$) is a mobile, colourless liquid, of peach-like odour; soluble in water, alcohol, and ether; of sp. gr. 0·926 and b.p. of 54·5° C.; used in manufacturing artificially prepared rum and arrack, and otherwise for flavouring purposes.

Ethyl Nitrate (**Nitric Ether**) ($C_2H_5NO_3$) is a colourless, mobile, inflammable liquid of pleasant odour, sp gr. 1·116 and b.p. 87·6° C.; soluble in water and alcohol, and prepared by heating a mixture of alcohol, urea nitrate, and nitric acid, followed by distillation.

Ethyl Valeriate ($C_2H_5.C_5H_9O_2$) is a colourless liquid of pleasant odour, of sp. gr. 0·8765 and b.p. 135° C.; soluble in water, alcohol, and ether, and used in compounding perfumes, etc.

Monobasic acids such as nitric acid yield only one kind of ester, termed "normal or neutral esters," but dibasic acids yield two series, termed "acid esters" and "neutral esters"; thus ethyl nitrate is $(C_2H_5)NO_3)$, while there are the two ethyl sulphates $(C_2H_5),HSO_4$ and $(C_2H_5)_2SO_4$. The acid esters as a class are odourless, readily soluble

ESTERS (*Continued*)—

in water, much less stable than the neutral series, and cannot be volatized without decomposition.

The fats, palmitin, stearin, and olein are solid esters, or glyceryl esters (glycerides) of respectively palmitic, stearic, and oleic acids, and are resolved by hydrolysis into glycerol (glycerine) and the several fatty acids; thus tristearin—

$$C_3H_5(C_{18}H_{35}O_2)_3 + 3KHO \text{ (potassium hydroxide)} = 3K(C_{18}H_{35}O_2) \text{ (potassium stearate)} + C_3H_5(OH)_3 \text{ (glycerol).}$$

The monoglycerides and the diglycerides are, it is believed, absent from natural freshly prepared fats and oils. (See Fats, Glycerides, and Soaps.)

Many of the esters form part of the odorous constituents of essential oils, and some of the better-known commercial ones listed below are individually described in the context:

Amyl acetate
,, benzoate
,, borate
,, butyrate
,, formate
,, valeriate
,, salicylate
Benzyl acetate
,, benzoate
,, chloride
Butyl acetate
Butyl formate
Dimethyl sulphate
Ethyl aceto-acetate
,, salicylate
Geranyl acetate
Glyceryl tri-acetate
Methyl acetate
,, benzoate
,, salicylate
Tricresyl phosphate
Triphenyl ,,

The amyl esters of formic, acetic, and hexoic (caproic) acids are among the odorous constituents of apples, and many esters are used in perfumery and for flavouring fruit essences, etc. (See Nitric Esters.)

ET—A prefix sometimes used for ethyl radical C_2H_5—.

ETCHING—See Fluorine.

"**ETELINE**"—See Solvents.

ETHANAL—See Aldehydes (Ethyl).

ETHANE or ETHYL HYDRIDE (C_2H_6)—See Hydrocarbons.

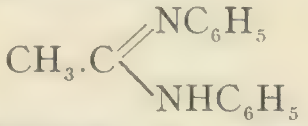
ETHANOL—Ethyl alcohol. (See Alcohols.)

ETHANOLAMINES—See Triethanolamine.

ETHENE (**Ethylene, Olefiant Gas**)—See Olefiant Gas, under Hydrocarbons.

ETHENOL—See Vinyl Alcohol.

ETHENYL—The radical $CH_3C\vdots$ as it exists, for example, in the crystalline base ethenyl-diphenyl amidine—



$$CH_3.C \begin{cases} = NC_6H_5 \\ - NHC_6H_5 \end{cases}$$

ETHER or ÆTHER (**Medium**) is a purely "hypothetical medium generally regarded as possessed of great elasticity and extreme tenuity, supposed to pervade all space, the interior of solid bodies not excepted, and to be the medium of transmission of light and heat" (Webster).

ETHER OR ÆTHER (*Continued*)—

To the author's chemical mind, however, it is inconceivable that the interstitial spaces of matter—as, for example, an atmosphere of hydrogen gas—can be occupied by this hypothetical æther. So far as such a conception is tenable, the result would be a mixture of the two things, and the æther must have *some* mass and properties and be detectable by them. That this view is correct some evidence has been recently forthcoming, S. Eddington finding reason to believe that the space between the stars and between them and the earth is not empty, but is filled with a tenuous cloud of matter.

Oliver Lodge has endorsed the opinion that mechanical forces cannot be exercised across really empty space in the completest sense, but chemically there is no empty space, but only attenuated atmospheres; and his reasoning appears to be paradoxical, for while he has described matter and æther as distinct things, yet at other times he has also described matter as essentially composed of this hypothetical æther denser than any form of matter.

Meanwhile there is absolutely no evidence of the existence of this postulated æther. (See Atoms, Matter, Occlusion, Porosity, and Vacuum; Dr. Jean's "Kelvin" Lecture referred to in *Nature,* March 7, 1925, and *Atomic Structure,* by W. C. Reynolds (Longmans, Green and Co.).)

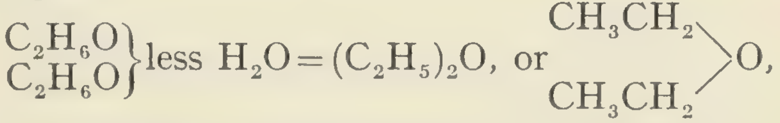
ETHER (Nitrous)—See Nitrous Ether.

ETHEREAL—Nature of ether; light, volatile.

ETHEREAL SALTS—See Esters.

ETHERIFICATION—The process of preparing ethers.

ETHERS (PROPER) (or ALKYL-OXIDES) are a class of compounds which may be described as the anhydrides of the corresponding alcohols or oxides of the organic radicals, as will be seen by comparison of the formulæ here given:



$$\left.\begin{matrix}C_2H_6O\\C_2H_6O\end{matrix}\right\}\text{less } H_2O=(C_2H_5)_2O,\text{ or }\left.\begin{matrix}CH_3CH_2\\CH_3CH_2\end{matrix}\right>O,$$

representing 2 molecules of ethyl alcohol, from which a molecule of water is abstracted by the action of sulphuric acid at 140° C. The ethers, in other words, correspond in relation to the alcohols as metallic oxides to their hydroxides—C_2H_5HO ethyl alcohol, $(C_2H_5)_2O$ ethyl ether; $NaHO$ sodium hydroxide, Na_2O sodium oxide.

Compound or mixed ethers are those in which the alcohol radicals are different.

Ethyl Ether, or Diethyl Ether, also commonly known by the names of "sulphuric ether" and "vitriol ether," is a mobile liquid of characteristic odour, soluble in alcohol, slightly soluble in water, very volatile and inflammable. It is prepared by distillation following upon the action of sulphuric acid on ethyl alcohol, and can also be made by passing alcohol vapour at 250° C. over specially prepared aluminium oxide. (See Clark and others, *J.S.C.I.*, 1925, **44,** B, 1011; and S. K. Jatkar and H. C. Watson on the use of potassium alum as a catalyst for

ETHERS (*Continued*)—

the production of ether (*J.S.C.I.*, 1926, **45,** 168 T).) It absorbs oxygen from the air, forming some compound which yields hydrogen dioxide with acidified water. Some recent experiments with respect to the nature of this autoxidation have been described by H. King (*J.C.S.*, 1929, p. 738). It boils at 34·9° C., has a sp. gr. of 0·72 at 17·4° C., and is an excellent solvent of oils, fats, and many organic substances. Apart from its extensive use as an anæsthetic, it is used commercially in the colour industry and in the preparation of collodion, smokeless gunpowder, etc. It has been found by Baker that the vapour density of ether dried for ten years is 81·7—that is, more than double the normal one.

When a mixture of ether vapour and air is allowed to expand suddenly into an evacuated tube it ignites. For a report on the ignition of ether at low temperatures by H. B. Dixon see *Lancet*, 1926, **210,** 258.

Methyl Ether $(CH_3)_2O$ is gaseous at ordinary temperatures, but liquefies at $-20°$ C., and is prepared on a considerable scale for the production of artificial cold by its volatilization.

ETHIDES—Combinations of metals with the radical ethyl, such as zinc ethide $(Zn(C_2H_5)_2)$.

ETHINE—See Acetylene.

ETHYL—The radical CH_3CH_2, or C_2H_5, as contained in ethyl alcohol (C_2H_5HO). The preparation of free ethyl and some of its properties are described by Paneth and Lautsch (*B.C.A.*, 1930, A, 735). (See Radicals.)

ETHYL ACETATE—See Esters.

ETHYL ALCOHOL—See Alcohols.

ETHYL ALDEHYDE—See Aldehydes.

ETHYL BENZOATE—See Esters.

ETHYL BROMIDE (**Monobromoethane**) (C_2H_5Br)—A liquid substitution product of ethane, of sp. gr. 1·468 and b.p. 38·4° C., soluble in alcohol and ether; used as a local anæsthetic, also for the preparation of tetraethyl lead, and the relief of migraine, asthma, and convulsions.

ETHYL BUTYRATE—See Esters.

ETHYL CAPRYLATE—See Esters.

ETHYL CARBONATE $((C_2H_5)_2CO_3)$, produced by interaction between ethyl iodide and silver carbonate, is a liquid of pleasant odour, sp. gr. 0·978, and b.p. 126° C.; soluble in alcohol, but not in water, and used as a solvent.

ETHYL CHLORIDE (**Monochlorethane**) (C_2H_5Cl) is at ordinary temperature a gas which is easily condensed to a colourless liquid state. It is a by-product in the manufacture of chloral; boils at 12·5° C., and is soluble in alcohol and ether. It is produced by passing dry hydrochloric acid gas into ethyl alcohol in presence of zinc chloride, and manufactured by mixing strong sulphuric acid with alcohol, and after standing some time, followed by dilution with water and addition of some potassium chloride, distilling the mixture.

ETHYL CHLORIDE (*Continued*)—

A series of chlorine substitution products may be obtained from it, isomeric with those obtainable from ethylene dichloride, the last term C_2Cl_6 being identical, but those derived from ethyl chloride are not decomposed by alcoholic potash and boil at different temperatures from the other series.

Mixed with a small quantity of chloroform, it is a particularly safe anæsthetic, and exercises a prolonged effect; while it does not attack metals, and constitutes a very convenient material for refrigeration, particularly when rendered non-inflammable by means of methyl-bromide. (See Ethylene Dichloride.)

ETHYL CINNAMATE—See Esters.

ETHYL ETHER—See Ethers.

ETHYL FORMATE—See Esters.

"ETHYL GASOLINE"—Anti-knock motor fuel. (See Motor Spirit.)

ETHYL NITRATE—See Esters.

ETHYL NITRITE—See Nitrous Ether.

ETHYL PETROL (PRATT'S)—A proprietary brand of anti-knock motor spirit stated to contain tetra-ethyl lead, ethylene dibromide, halowar oil (monochlorgraphthalene), and red aniline dye.

ETHYL VALERIATE—See Esters.

ETHYLAMINE ($C_2H_5.NH_2$)—In the anhydrous state this compound is a colourless, mobile, inflammable liquid of sp. gr. 0·6984 at 8° C. and b.p. 18·7° C. It burns with a yellow flame, is soluble in water, but may be expelled from the solution by boiling.

It can be prepared in a number of ways, including the decomposition of ethyl cyanate with potassium hydroxide, the action of ammonia upon ethyl bromide, and the catalytic (exothermic) action of a silica or alumina gel upon ethyl alcohol and ammonia:

$$C_2H_5.OH + NH_3 = C_2H_5.NH_2 + H_2O.$$

(See Amines, and G. W. Dorrell (*J.C.S.*, 1925, cxxvii., 2399).)

Like other amines of its class, it has an alkaline reaction, ammoniacal odour, and combines with hydrochloric acid, etc., to form salts.

ETHYLATION—Introduction of the ethyl group into compounds. (See J. McLang, *C.T.J.*, 1928, **83**, 143.)

ETHYLENE (OLEFIANT GAS), m.p. $-169°$ C., b.p. $-103°$ C.—A gas, being the simplest compound containing the ethylenic linkage or double bond between two carbon atoms. The polymerization reactions of ethylene is the subject of a paper by H. M. Stanley (*J.S.C.I.*, 1930, **49**, 349 T). It is used for fruit preservation and the synthesis of ethyl alcohol. (See Alcohol (Ethyl), Fruits, and Hydrocarbons (Olefines).)

ETHYLENE DIAMINE ($C_2H_4(NH_2)_2$)—A colourless liquid, b.p. 123° C. and sp. gr. 0·902, made from a mixture of ethylene chloride and ammonia, followed by distillation; used as a solvent of albumin, fibrin, casein, sulphur, etc., and as an emulsifying agent.

ETHYLENE DICHLORIDE (**Ethylene Chloride, Dutch Liquid,** $C_2H_4Cl_2$ or $CH_2Cl.CH_2Cl$) is prepared by the action of chlorine on acetylene or by the direct combination of ethylene and chlorine at 0° C., with subsequent distillation. It is a heavy, oily, colourless liquid, insoluble in water, soluble in alcohol and ether, and of pleasant odour (somewhat like chloroform). It is now made in considerable quantities in the U.S.A. from natural gas containing a high percentage of ethylene. It crystallizes at a low temperature, boils at 83·5° C., has a density of 1·2808 at 0·4°, finds some use as an anæsthetic, and constitutes a valuable solvent of oils, fats, waxes, certain resins, and gums. (See Solvents.) It is isomeric with ethylidene chloride ($CH_3.CHCl_2$), obtained by the chlorination of C_2H_5Cl (ethyl chloride).

By the continued action of chlorine, it yields a series of other substitution products—viz., $C_2H_3Cl_3$, $C_2H_2Cl_4$, C_2HCl_5, and C_2Cl_6, of boiling-points respectively 115°, 137°, 154°, and 185° C., the final member, C_2Cl_6, being identical with the substance of same formula obtainable from ethyl chloride.

When these various ethylene chlorides are subjected to the action of alcoholic potash they are decomposed, and yield the so-called chlorethylenes as follows:

$C_2H_4Cl_2$ gives chlorethylene, C_2H_3Cl, by loss of HCl.
$C_2H_3Cl_3$ gives dichlorethylene, $C_2H_2Cl_2$, by loss of HCl.
$C_2H_2Cl_4$ gives trichlorethylene, C_2HCl_3, by loss of HCl.
C_2HCl_5 gives perchlorethylene, C_2Cl_4, by loss of HCl.

Ethylene chloride, when decomposed by alcoholic potash, yields acetylene. (See S. H. Killeffer (*Ind. Eng. Chem.*, May, 1927) and *C.T.J.*, 1927, **80**, 513; also Ethyl Chloride and Solvents.)

ETHYLENE GLYCOL (**Alcohol**) ($CH_2OH.CH_2OH$)—A clear, sweet, syrupy liquid of sp. gr. 1·114 at 15·5° C. and b.p. 198·0° C., soluble in water, alcohol, and ether. It is made in large quantities from the ethylene of natural gas and that produced by cracking hydrocarbon oils; ethylene chloride being first obtained by use of hypochlorous acid, and then converted into the glycol. It can also be prepared from ethylene iodide by silver acetate and saponification. A 35 per cent. solution in water freezes at about $-20°$, and a 45 per cent. by volume solution is recommended as an "anti-freeze" material for motor-car radiators, meeting severe conditions. It is used for making nitro-glycol and ethanolamines; is a valuable lubricant for wool-spinning (dispensing as it does with the costly scouring for oil elimination after spinning); serves as a solvent for certain dyes and other substances; and is superior to glycerol for some purposes, including its use as an anti-freeze agent. (See T. H. Fairbrother (*Ind. Chem.*, 1928, iv., 179).)

ETHYLENE OXIDE (CH_2CH_2O)—See Fumigation.

ETHYLIDENE CHLORIDE—See Dichloro-ethane.

EUCAINE ($C_{15}H_{21}NO_2$)—A white, crystalline, organic compound used as a cheap substitute for cocaine. (See Benzamine Hydrochloride and Benzamine Lactate.)

EUCALYPTOL (Cineol)—See Cineol and Essential Oils.

EUCALYPTUS OILS—These oils vary with the species (ranging from very large trees to dwarf bushes of the genus Myrtaceæ) from which they are produced, and as there are upwards of 300, the oils of commerce are often of mixed character, the several constituents (phellandrene, cineol, citral (geranial), terpenes, etc.) varying accordingly in their proportions. A sesquiterpene named aromadendrene is a constituent of some varieties of oils derived from the genus Eucalyptus. See Briggs and Short (*J.C.S.*, 1928, p. 2524). They are all soluble in alcohol, ether, and chloroform, and are used in medicine, in perfumery, and the cheaper ones in the flotation process of ore concentration. Their calorific value is high, and they can be mixed with petrol, benzene, etc., acting as decarbonizing agents and thus keeping cylinders and pistons of internal combustion engines free, to some extent, from carbon.

The **Globulus** variety is generally preferred to the amygdalina oil on account of its superior content of cineol and its density of odour, but as sanitary agents there is little to choose between the many kinds of oil that are available. The globulus oil has a sp. gr. of from 0·91 to 0·93 at 15° C.; ref. ind., 1·462 to 1·469 at 20° C.; opt. rot., +10° to −10° at 20° C.; and contains from 50 to 80 per cent. of cineol (eucalyptol) ($C_{10}H_{18}O$), together with some pinene, phellandrene, and cymene.

The **Amygdalina Oil** has a sp. gr. of 0·855 to 0·89 at 15° C.; ref. ind., 1·474 to 1·480 at 20° C.; and opt. rot. of −25° to −80° at 20° C. It contains phellandrene as its chief constituent, 5 to 25 per cent. cineol, and is not nearly so pungent in odour as the globulus oil.

The **Phellandra Oil** has a sp. gr. at 15° C. 0·902 to 0·905 and a cineol content of 25 to 35 per cent., and consists chiefly of phellandrene, cineol, pinene, terpineol, and geraniol.

The **Citriodora Oil** has a sp. gr. of 0·87 to 0·905 at 15° C.; ref. ind. of 1·455 to 1·460 at 20° C.; and opt. rot., −1° to +2° at 20° C. It has a characteristic odour, and consists chiefly (85 to 95 per cent.) of citronellal.

The **Oleosa Oil** has a camphoraceous odour and a sp. gr. of 0·911.

The **Dumoso Oil** has a delicate odour and sp. gr. 0·931.

The **Rostrata Oil** has a sp. gr. of 0·918.

The **Piperita Oil,** from the leaves and terminal branchlets of *E. piperita,* is yielded to the extent of from 2·15 to 8·0 per cent., and contains 44 per cent. piperitone and phellandrene. (See Menthol and Piperitone.)

The **Dives Oil**—sp. gr. 0·8892 to 0·9063; opt. rot., −58° to −78°; ref. ind. at 20° C., 1·4784 to 1·4806—contains, among other constituents, 4-terpineol b.p. 208° to 212° C. 760 m.m. and 1 : 4 terpin m.p. 137° to 138° C. (Schimmel and Co., *B.C.A.*, 1929, B, 453). It also contains from 40 to 53 per cent. piperitone. (See Penfold and Morrison concerning varieties of *E. Dives* (*B.C.A.*, 1929, B, 537, and 1930, B, 685); Stephan and Düker (*B.C.A.*, 1931, B, 514); and Thymol.)

According to the late Mr. Bosisto, the essential oil contained in *Eucalyptus amygdalina* (or narrow-leaved peppermint tree) is 3·313 per cent.; *E. oleosa,* 1·25 per cent.; *E. leucoxylon,* 1·06 per cent.; *E.*

EUCALYPTUS OILS (*Continued*)—

goniocalyx, 0·914 per cent.; *E. globulus* (or blue gum tree), 0·719 per cent.; *E. obliqua* (or stringy-bark tree), 0·5 per cent.

According to M. Raveret-Wattel, that contained in *E. sideroxylan* is 1·00 per cent.; in *E. fabrorum*, 0·50 per cent.; *E. woolsii*, 0·18 per cent.; and *E. rostrata* (or red gum tree), 0·06 per cent. The oils obtained by steam distillation of the leaves and terminal branches of certain cultivated varieties are superior to the ordinary commercial supplies. (See A. R. Penfold (*B.C.A.*, 1927, B. 28; B, 858); A. R. Penfold on "Commercial Eucalyptus Oils" (*B.C.A.*, 1932, B, 128); and Essential Oils.)

The red gum tree yields a substance known as Botany Bay Kmo; the *E. robusta* also yields a red gum, while the *E. mannifera* yields a sweet exudation from its bark and leaves resembling manna in sweetness and aperient character.

EUCLASE (*prismatic emerald*)—A native silicate of aluminium and glucinum ($2GeO,Al_2O_3,2SiO_2,H_2O$); crystal system, No. 5; sp. gr. 3·1.

EUDIOMETER—A simple form of this apparatus, as used for the examination of gases, is a long glass tube, closed at the one end and open at the other, graduated into cubic centimetres. At the closed end, thin wires of platinum are fused through the glass, and thence pass outside, so that they can be connected with the wires of an electric coil. In using it to demonstrate the composition of water, a mixture of 2 volumes of hydrogen and 1 volume of oxygen is introduced into the tube, which is then inverted and placed with its open end in a trough of mercury. Upon causing an electric spark to pass from end to end of the wires, the gases combine with explosive force. In this way, it is found that these respective quantities combine to form water. (See Voltameter.)

Using a mercury bath, this form of eudiometer may be used also to demonstrate the proportion of oxygen present in a given volume of air by inverting the graduated tube containing some air (the rest of the tube being occupied by mercury) over the bath, and introducing, by means of a pipette having a recurved end, some few cubic centimetres of a mixture of 1 part of pyrogallic acid in 6 parts of water rendered alkaline with caustic potash. This solution rises up through the mercury in the tube, absorbs the oxygen, becomes dark brown in colour in consequence, and leaves the nitrogen unabsorbed, the diminution in volume thus becoming apparent. (See Organic Analyses.)

EUGENOL—See Cloves.

"EULANS"—The name "Eulan" was first of all given to a German preparation of metallic derivation, stated to be an odourless, colourless, inorganic salt, harmless to human skin and fabrics, and affording permanent protection against moth in articles of clothing. An aqueous solution is used when articles have to be immersed, or one of solution in benzine for dry cleaning. Since then a series of "Eulans" have appeared on the market, applicable for the moth-proofing of wool, etc. Some of these entail the use of sulpho- and carboxylic acids of aromatic hydrocarbons, and others that of aromatic sulphonic chlorides, etc. (See *C.T.J.*, 1927, **81**, 391, and 1928, **83**, 574.)

EUONYMIN—An oleo-resinous body from the bark of the U.S.A. spindle-tree (*Euonymus atropurpureus*), insoluble in water but soluble in alcohol, and having tonic and laxative properties.

EUPHORIN (Phenylurethane)—Prepared from ethyl chloroformate and aniline, possessing analgesic character.

EUROPIUM (Eu)—Atomic weight, 152. An exceedingly rare element belonging to the Terbium group, of which little is known, occurring in *samarskite, orthite, cerite, gadolinite,* etc. Its oxide is Eu_2O_3, and other compounds are referred to by M. P. B. Sarkar (*B.C.A.*, 1927, A, 325).

"EUSOL"—A proprietary antiseptic solution containing hypochlorous acid; prepared by interaction between so-called chloride of lime and boric acid.

EUTECTIC—A term given to a solidified mixture of solute and solvent of the lowest melting-point; for example, a molten mixture of zinc (m.p. 419° C.) and cadmium (m.p. 321° C.) yields by solidification of one or other metal during cooling a eutectic mixture which contains 73 per cent. cadmium and solidifies at 270° C. (See Dystectic Mixture and Solution.)

EUXAMITE—A radio-active radium earth found in Brazil.

EUXENITE—A complex mineral containing erbium, titanium, cerium, etc.

EVAPORATION—The passage from the liquid to the vaporous state, as when water is evaporated by the agency of heat into steam. Many liquids may be concentrated by means of evaporation, the excess of water or other solvent which holds the chemical substance in solution being thereby dissipated. The process is often conducted by way of distillation from a retort, so that the solvent, if valuable, can be condensed and recovered. (See Distillation.)

There are numerous types of evaporating plant, and, while one may be excellent for use in connection with a liquid that retains that state to the end, it may be quite unsuitable for dealing with a liquor that deposits solid matter in course of evaporation.

The "heat pump" is an apparatus for economizing heat in processes of evaporation, the vapour from the evaporator being taken to a compressor, in which its pressure, and consequently its temperature, are raised to such degree that it is rendered capable of service for assisting in the evaporation of a further quantity of liquid, for which purpose it is returned to the evaporator. This method is successfully employed in sugar-refining, paper-making, and other industries, and promises to be of great value in drying peat and lignite.

Evaporation is retarded to some extent by salts and other soluble substances in solution, as compared with that of water.

Vacuum evaporation is largely used in commercial practice, and varieties of so-called film evaporators include the "Lillie," "Yaryan," "Schwager," "Claassen," "Grenier," and "Kestner." (See *C.T.J.*, 1924, **74,** 123, and 1924, **75,** 94.)

A new rapid-flow evaporator ("Vogelbusch") is described in the *Ind.*

EVAPORATION (*Continued*)—

Chem., 1926, ii., 550, and data concerning evaporating equipment (*Ibid.*, 1928 (supplement), iv., 461).

In the conversion of liquid to vapour, the vapour pressure is definite for every temperature, and the b.p. of the liquid is that temperature at which the vapour pressure is equal to that of the external atmosphere.

The evaporation unit (ev.u.) is the amount of heat required to raise 1 lb. water at 100° C. into saturated steam at the same temperature, and consequently at the atmospheric pressure of 14·7 lbs. per sq. inch.

Evaporating Basins are employed for the concentration of liquids, also to obtain substances in a crystallized condition, or for drying solid masses or pasty mixtures by heating. They are made of various sizes from 2 inches in diameter up to 12 inches or more, the larger ones being of porcelain, glass, and silica. Some smaller ones are made of silver, aluminium, platinum, nickel, and tantalum (choice being made according to the nature of the chemicals to be dealt with), and all are preferably provided with a lip to facilitate the transfer of their liquid contents as required. See "Technical Notes on Evaporation," by Hartland Seymour (*Ind. Chem.*, 1925, i., 254); J. A. Reavell on "Some New Aspects of Evaporation" (*Chem. and Ind.*, 1930, **49,** 325); "Vapour Compression Evaporators," by A. J. V. Underwood (*C.T.J.*, 1926, **78,** 153, 217, 283, and 315); *C.T.J.*, 1927, **80,** 561; *Evaporation*, by A. L. Webre (Chemical Catalog. Co., Inc., N.Y.); and Hausbrand's book on *Evaporating, Condensing, and Cooling Apparatus* (E. Benn, Ltd.).

EVAPORIMETER—An instrument for ascertaining the amount of liquid evaporated in a given time.

"EVERSOFT" L.D. POWDER—A new approved low-density explosive for use in safety-lamp coal mines. (See *C.T.J.*, 1931, **89,** 632, and Drying.)

EXHALATION—The act of exhaling (breathing out) or passing out of vapours.

EXOSMOSIS—See Osmosis.

EXOTHERMIC COMPOUNDS—See Heat.

EXPANSION—Occupying a greater space. Many metals, other solid bodies, liquids, and gases (in particular) are expanded by heat.

EXPLOSION RISKS (in Industries)—See Dusts and Flash-point.

EXPLOSIONS—See E. W. Steacie (*Chem. and Ind.*, 1932, **51,** 208), Detonators, Flame, and Flash-point.

EXPLOSIVES—Explosives are substances which, under the influence of heat or shock, or both, are instantly resolved into gases occupying at the high temperature of explosion comparatively enormous volumes, and consequently exerting tremendous pressure, which may be utilized to disrupt the objective or drive projectiles out of guns. They may consist of bodies such as nitro-glycerine and nitro-cellulose, which are explosive in themselves, or mixtures of substances which, separately, are or may be non-explosive, but when intimately mixed are capable of being exploded either by ignition or detonation.

EXPLOSIVES (*Continued*)—

Gunpowder is a mechanical mixture of nitre, or Chile nitre, with charcoal and sulphur in proportions of about 75, 15, and 10 respectively, and is still largely employed for blasting purposes, although it has ceased to be used as a military propellant, or nearly so. The nitre supplies the oxygen necessary for burning up the carbon and the sulphur, at the same time yielding nitrogen gas. It is a so-called "low explosive," while the "high explosives" have a velocity of explosion some 500 times greater. These high explosives are rich in nitrogen, and, when detonated, furnish large quantities of that gas and others which are enormously expanded by the heat generated by the chemical changes which take place, so that they amount to from 10,000 to 15,000 times the volume of the explosive substance itself.

Just as nitre supplies the oxygen necessary to burn the charcoal and sulphur contained in gunpowder, so (by chemical means) hydrogen can be removed from cotton (cellulose), glycerol, phenol, toluene, etc., and be substituted by groups of the radical NO_2, which contain and supply the oxygen essential to the combustion of the associated carbon and hydrogen, the carbon being converted into gaseous oxides and the hydrogen into steam, while at the same time the nitrogen is also set free in the form of gas. Some of these substances, and their nitrated forms, may be roughly indicated as follows:

Cellulose ($C_6H_{10}O_5$) is chemically changed into nitro-cellulose or gun-cotton ($C_{12}H_{14}O_{10}(NO_2)_6$):

$$2C_6H_{10}O_5 + 6HNO_3 = C_{12}H_{14}O_{10}(NO_2)_6 + 6H_2O.$$

Glycerol ($C_3H_8O_3$) becomes changed to tri-nitro-glycerol ($C_3H_5(O.NO_2)_3$ or $C_3H_5(NO_3)_3$); phenol (C_6H_6O) becomes changed to tri-nitro-phenol ($C_6H_2(NO_2)_3OH$), and toluol, or toluene (C_7H_8), becomes changed to tri-nitro-toluol ($C_7H_5(NO_2)_3$).

Nitro-Glycerol is a pale yellow, odourless, heavy body of oily consistency and sp. gr. 1·6, obtained by the action of strong nitric acid upon glycerol, and is soluble in alcohol and ether. Robertson's apparatus is designed for following its decomposition by the spectroscopic estimation of the evolved nitric peroxide. When decomposed by explosion, the chemical changes that occur are represented by the following equation, from which it will be seen that the whole of the oxygen that is required is self-supplied, and that all the products are gaseous at the temperature of the explosion:

$$2(C_3H_5N_3O_9) = 6CO_2 + 5H_2O + 3N_2 + O.$$

The heat developed by the explosion of 1 grm. of nitro-glycerol amounts to 1,459 calories.

Nitro-Glycol ($C_2H_4(NO_3)_2$) is prepared by slowly adding ethylene glycol to a mixture of nitric and sulphuric acids. It is a colourless, mobile liquid devoid of any appreciable odour, sweetish in taste, of sp. gr. 1·4962 at 15° C., and freezing-point $-22·3°$ C. It is finding increasing application as a less sensitive explosive than nitro-glycerine, both alone and in admixture with that substance. (See W. H.

EXPLOSIVES (*Continued*)—

Rickenbach (*American Industrial and Engineering Chemistry*, November, 1926, p. 1195).)

Dynamite, largely used for blasting purposes in mines, and in respect of hard masses of certain materials which go to the making of fertilizers such as acid phosphate and otherwise, is a mixture of nitroglycerol and the infusorial earth named kieselgühr, and has given a velocity wave of 6,000 metres per second.

"Blasting gelatine"—a stiff jelly—is the strongest of all nitroglycerine explosives, and other varieties consist of a thin jelly of nitroglycerine thickened with from 3 to 6 per cent. collodion cotton worked up into a plastic mass with suitable proportions of potassium nitrate and wood-meal.

Nitro-glycerine is used in the preparation of vaso-dilators; its explosives freeze at 8° C., and have to be thawed before use.

Tri-Nitro-Toluol (T.N.T.) (Tri-Nitro-Toluene) is obtained by the graduated action of strong nitric acid upon toluol (toluene), in the form of yellow prismatic crystals of m.p. 80·5° C., soluble in alcohol and ether but not in water. It has replaced picric acid to a large extent as a filling for shells, exploding with great force when detonated with mercuric fulminate, and being more stable in character and cheaper.

Picric Acid, or tri-nitro-phenol ($C_6H_2(NO_2)_3OH$), is obtained by the graduated action of strong nitric acid upon phenol (carbolic acid), and is itself a high explosive. It has given a velocity of 7,700 metres per second. Various mixtures of it with *collodion*—a nitrated cellulose prepared from gun-cotton by dissolving it in mixtures of ether and alcohol or other solvent—in compressed and molten forms constitute the explosives *melinite* and *lyddite*. Its use was largely superseded during the Great War by the Germans' employment of tri-nitro-toluene, and by this country using the same compound generally mixed with ammonium nitrate. (See Picric Acid.)

Gun-Cotton, or nitro-cellulose (formulated sometimes as $C_6H_7O_5(NO_2)_3$, and at others $C_{12}H_{14}O_{10}(NO_2)_6$), is obtained by the graduated action of nitric and sulphuric acids upon cellulose (cotton-waste), several stages of nitration being possible. The sulphuric acid is employed to prevent dilution of the nitric acid by absorption of the water set free during the nitration, and the process is carried on until the product contains about 13·1 per cent. nitrogen. Smokeless gunpowders and most of the violent propellants contain gun-cotton.

Dry gun-cotton is one of the most dangerous explosives, as when dry and warm it is very liable to explosion by friction.

Tri-nitro-cellulose is a yellowish, amorphous substance soluble in alcohol, ether, benzol, acetone, amyl acetate, etc.

The heat developed by the explosion of 1 grm. of gun-cotton is 1,010 calories.

See note, "Considerations on the Nitration of Cellulose," reproduced in the *Ind. Chem.*, 1926, ii., 234.

Cordite is an important military propellant, and is a mixture of

EXPLOSIVES (*Continued*)—

gun-cotton and nitro-glycerine dissolved in acetone, and thickened and rendered more stable with about 5 per cent. of vaseline. The excess of acetone is afterwards evaporated off from the gelatinous mass, which is prepared in cord form.

"**Gelignite**" is a mixture of nitro-glycerine, nitro-cellulose, wood-pulp, and potassium nitrate.

"**Amatol**"—A commercial and military explosive made by admixing 20 parts T.N.T. with 80 parts ammonium nitrate, which gradually superseded other high explosives including picric acid, as a filling for shells during the Great War, as, although less rapid and shattering than T.N.T., it gives greater flame, is cheaper, and practically smokeless, due to the excess of oxygen provided by the ammonium nitrate, the ideal proportions to produce complete combustion being given by the equation:

$$21NH_4NO_3 + 2C_6H_2(NO_2)_3.CH_3 = 14CO_2 + 47H_2O + 24N_2.$$

"**Ammonal**"—An explosive of the ammonium nitrate class, resembling amatol, containing finely divided aluminium in admixture.

"**Cheddite**" is an explosive, the chief ingredient of which is potassium chlorate, made up with proportions of nitro-naphthalene or di-nitro-toluene and from 5 to 6 per cent. castor oil.

"**Blastine**" is another explosive of the chlorate type.

"**Roburite**" is the name of a smokeless and flameless mining explosive, in the compounding of which chloro-di-nitro-benzene is employed (as also in "Bellite"), in admixture with ammonium nitrate.

"**Tonite**"—A compressed explosive compounded of gun-cotton and barium nitrate used for submarine demolition, for distress signal work, and for blasting.

"**Umbrite**" is an explosive containing 49 parts of nitro-guanidine, 38 parts ammonium nitrate, and 13 of silicon; stated to be but slightly hygroscopic, and well retaining its explosive power even when moist.

The amount of blasting explosives (excluding cordite, smokeless powder, sporting ammunition, etc.) manufactured in this country before the war was about 17,500 tons per annum.

Liquid oxygen and liquid air explosives are made by saturating absorptive and combustible materials, such as cellulose, lamp-black, soot, cork-meal, or infusorial earth, with the liquefied gases, and with or without various metallic powders. They are stated to be stronger than black powder, and can be used for some purposes instead of gunpowder and dynamite; also in mine rescue apparatus and for airships. For electric shot firing, fuses with fulminate detonators are used; for cartridges, P, simple fuses, and in other cases special detonators. (See G. St. J. Perrott, *J.S.C.I.*, 1925, **44,** B, 526; also "Cupren" and Oxygen.) Liquid carbon dioxide enclosed in hollow steel cylinders which can be shattered by an electric current conveyed to a mild steel disc on the bombs have also been used for blasting purposes in coal-mines.

Among authorized explosives for use in coal-mines are the following:

EXPLOSIVES (*Continued*)—

"Ammodyne."

Nitro-glycerine	9 to 11 parts.
Ammonium nitrate	48 ,, 51 ,,
Sodium nitrate	8 ,, 10 ,,
Ammonium oxalate	17 ,, 19 ,,
Wood-meal (dry at 100° C.)	11 ,, 13 ,,
Moisture	2 ,,

"Capexco."

Nitro-glycerine	32 to 34 parts.
Nitro-cotton	0·5 ,, 1·5 ,,
Sodium nitrate	24 ,, 25 ,,
Ammonium oxalate	30 ,, 32 ,,
Wood-meal (dry at 100° C.)	8 ,, 10 ,,
Moisture	2 ,,

"Celmonite."

Ammonium nitrate	65·5 to 68·5 parts.
Tri-nitro-toluol	10·5 ,, 12·5 ,,
Sodium chloride	19·5 ,, 21·5 ,,
Moisture	2 ,,

"Ligdynite."

Nitro-glycerine	25 to 27 parts.
Sodium nitrate	27 ,, 29 ,,
Sodium chloride	10 ,, 12 ,,
Wood-meal (dry at 100° C.)	30 ,, 33 ,,
Moisture	2 ,, 4·5 ,,

"Superligdynite."

Nitro-glycerine	15 to 17 parts.
Ammonium nitrate	15 ,, 17 ,,
Sodium nitrate	23 ,, 25 ,,
Flour (dry at 100° C.)	10 ,, 12 ,,
Wood-pulp (dry at 100° C.)	19 ,, 21 ,,
Sodium chloride	9 ,, 11 ,,
Moisture	2 ,, 4 ,,

Fifty thousand tons of explosives are annually used in the British Empire in the coal and metal ores industries. (See Detonators.)

Explosives of the gelatine type are chiefly employed in metalliferous mining, all being based upon nitro-glycerine. They are plastic, and readily accommodate themselves to irregularities of structure, but they have the defect of being subject to freezing in cold weather. A new non-freezable variety is now on the market.

See W. Macnab's lecture (*J.S.C.I.*, 1922, **41**, 353 T); W. Cullen on "Industrial and Mining Explosives" (*J. Inst. Mining and Metallurgy*, October, 1923); description of explosives manufactured at Nobel's Ardeer factory (*Ind. Chem.*, 1926, ii., 525, and 1927, iii., 297); "Permitted Explosives in Fiery Mines," by W. J. Hiscock (*Ibid.*, 1925, i., 173); "Explosive Vapours and the Testing of Oil Tanks," by W. M.

EXPLOSIVES (*Continued*)—

Seaber (*Ibid.*, 1925, i., 247); "Gaseous Products of Explosion of Blasting Explosives," by J. Thorburn (*J.S.C.I.*, 1927, **46**, 358 T); "Detonation of Solid Explosives," by Laffitter and Patry (*B.C.A.*, 1931, B, 224); H.M. Inspectors' Annual Reports on Explosives (H.M. Stationery Office); works of E. de Barry Barnett (Baillière, Tindall and Cox); by A. Marshall (J. and A. Churchill); and P. Nasum on *Nitro-glycerine and Nitro-glycerine Explosives* (Baillière, Tindall and Cox); Bobbinite, "Eversoft," and Detonators.

"EXTERPEST"—A non-arsenical white powder introduced as a general insect exterminator, stated to be non-poisonous to human beings and animals, applicable among other purposes to growing cotton plants for preventing the ravages of the boll-weevil and those of the pink-worm and cup-worm parasites of the Egyptian and Indian cotton-fields. It consists mainly of a silica base which, with the assistance of lime extracts, acts upon the insects in such manner that the moisture of the body is absorbed, thus producing a total physical change.

EXTRACTION—Solvent action by means of which the soluble parts of a substance are extracted—as, for example, vanilla from vanilla beans, atropine from belladonna, caffeine from tea, cantharidin from Spanish fly, and santonin from worm-seed. An apparatus frequently used in such processes is a "reflux condenser"—a contrivance arranged so that the condensed vapour of the volatile solvent flows back again continuously into the containing vessel. A simplified apparatus for the extraction of aqueous solutions by means of less dense non-miscible solvents is described in *Chem. and Ind.*, 1931, **50**, 44. Descriptions of other laboratory extraction apparatus are given in the *Analyst*, 1913, **38**, 143; 1925, **50**, 153; 1928, **53**, 380; and 1931, **56**, 528; the *Ind. Chem.*, 1925, i., 448; illustrations of manufacturing plant (*Ibid.*, i., 89); and *J.S.C.I.*, 1931, **50**, 144 T. (See also Dephlegmate, Rectification, and Soxhlet Apparatus.)

EXTRACTS—Concentrated preparations obtained by evaporation of infusions made from plants, etc., or solutions of matters extracted by solvents from drugs and other materials. (See Extraction.)

FABRICS—See Textiles.

"FABRIKOID"—An American cotton preparation used as a substitute for raw materials, such as ivory, rubber, leather, amber, tortoiseshell, etc.

"FACTOCRETE"—A material compounded of chemically treated wood fibre, Portland cement, and other substances, prepared under great pressure, and used in the construction of dwellings; said to be two-thirds of the weight of concrete, and equally strong; mouldable to any shape.

FACTORY INSPECTION—See Annual Reports of the Chief Inspector of Factories and Workshops and those of the Alkali Acts Inspector (H.M. Stationery Office).

FADEOMETER—An apparatus designed to test the fastness of dyes, inks, paints, etc., to light, in which the light used is the violet carbon arc, being of uniform quality and intensity, unlike sunlight, which varies so

FADEOMETER (*Continued*)—
much in power at different times and places. In case of dyed fabrics, exposure of one hour in the fadeometer is stated to have the same fading effects as 1·3 hour's exposure to June sunlight. (See Light, p. 535.)

FAHRENHEIT—See Heat.

FARADAY—See Electricity.

FARINA—Potato or corn starch, used in baking and confectionery, foodstuffs, maltose, and mucilage making, etc. A variety of farina, called "Farifeed," is specially used in making food for animals.

FARINACEOUS—Starchy.

FARMING—Chemistry. (See T. Russell (*Chem. and Ind.*, 1928, **47,** 1217); also Fertilizers, Soils, and Vegetation.)

FAT HARDENING—See Hydrogen (Hydrogenation, p. 461).

FATS—Most animal and vegetable fats, including suet, tallow, butter, and many of the various fish and nut oils, are mixtures of distinct fats or substances chemically termed triglycerides or "glyceryl esters," of stearic, palmitic, oleic, and other acids. In other words, these fats or esters are combinations of fatty acids and glycerol. The two former acids being solid and oleic acid fluid in their separate forms, the consistence of a fat or oil depends upon the relative proportion of these several fat constituents named individually stearin, palmitin, olein, etc. They all melt well below 100° C., and are all saponifiable, yielding soaps and glycerol by the process. (See Saponification.)

Information respecting the manner in which the fatty acids are combined with glycerol in natural fats is greatly lacking. The investigations of Hilditch and his associates have disclosed some differentiation between the constitution of animal and vegetable fats; seed or kernel fats, for example, show a tendency for all the fatty acids to be linked with glycerol in a more even distribution than occurs in animal fats. Their methods of research in this and other directions and the results thereof are described in various papers. There is evidence that carbohydrates constitute an intermediate stage in vegetable fat metabolism and some inconstancy of composition in the fats themselves, and these more recent methods of investigation have so far given a more satisfactory but not complete picture of the substances concerned. (See *J.C.S.*, 1927, p. 3106; *J.S.C.I.*, 1928, **47,** 261 T; *Chem. and Ind.*, 1929, **48,** 212; T. P. Hilditch and E. E. Jones (*Analyst*, 1929, **54,** 75); and B. C. Christian and T. P. Hilditch (*Ibid.*, 1930, **55,** 75).)

A number of fatty acids have been synthesized and some result from the oxidation of paraffin wax. (See Francis, Piper, and Malkin (*B.C.A.*, 1930, A, 1161), and Petroleum.)

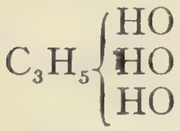
Tristearin as isolated from beef-fat is reported to melt at 71·2° C., and to have a sap. v. 189·6. Lard does not contain tristearin. Improved methods for determining the unsaponifiable matter in fats and oils have been described by E. L. Smith (*Analyst*, 1928, **53,** 632). The physical properties of some pure triglycerides is the subject of a paper by Joglekar and Watson (see *Analyst*, 1929, **54,** 117).

"Vegetable Oil Refining," as carried out in preparing oils for edible

FATS (*Continued*)—

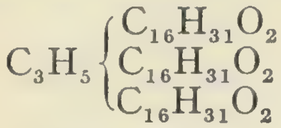
purposes, is the subject of an article by T. Andrews (*C.T.J.*, 1926, **79**, 585 and 616).

The constitution of fat is illustrated by showing the constitutional formulæ of glycerol and (for example) palmitin and stearin side by side:



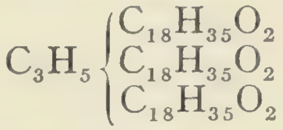
$$C_3H_5\left\{\begin{matrix}HO\\HO\\HO\end{matrix}\right.$$

Glycerol.



$$C_3H_5\left\{\begin{matrix}C_{16}H_{31}O_2\\C_{16}H_{31}O_2\\C_{16}H_{31}O_2\end{matrix}\right.$$

Tripalmitin.



$$C_3H_5\left\{\begin{matrix}C_{18}H_{35}O_2\\C_{18}H_{35}O_2\\C_{18}H_{35}O_2\end{matrix}\right.$$

Stearin or tristearin.

When stearin is saponified with caustic soda, the following change takes place: $C_3H_5(C_{18}H_{35}O_2)_3 + 3NaHO = 3Na(C_{18}H_{35}O_2) + C_3H_8O_3$—that is to say, sodium stearate (or soda soap) and glycerine (glycerol) are produced.

The manufacture of hardened fats is dealt with under the heading of Hydrogen (Hydrogenation).

Fats and fatty acids are largely used in the manufacture of soaps, candles, foodstuffs, and margarine; tallow and bone-fat and some oils are used in connection with the sizing of certain textiles to soften the effect of starch; whilst nut and fish oils have in recent years acquired growing importance on account of the ever-increasing demand for margarine. "Stearine" candles consist for the most part of stearic acid, some proportion of paraffin or other wax being added to prevent crystallization. The stearic acid is obtained by hydrolysis of the beef and mutton fats with either superheated steam, or dilute sulphuric acid, or lime and water. When steam is used, the glycerol distils over with the steam, the fatty acids being left behind.

In the "acid process" they are boiled with strong sulphuric acid, while the "fermentation process" depends upon the lipolytic action of certain enzymes, such as those contained in castor seed.

The "*Twitchell*" process of hydrolysing fats so as to obtain glycerol and fatty acids directly, without the use of alkalies or by heating under pressure, employs a fatty aromatic sulphonic acid as a reagent—for example, that obtained by allowing an excess of sulphuric acid to act on a solution of oleic acid dissolved in an aromatic hydrocarbon, such as benzene or naphthalene. According to one account, the constitution of Twitchell's reagent is $C_{18}H_{35}O_2,C_{10}H_6SO_3H$. The cleansed fat or oil is mixed with from 40 to 50 per cent. of distilled water containing about 2 per cent. of the reagent, and the mixture kept stirred and heated by means of an open steam coil for from ten to fifty hours, according to the nature of the fat. At the conclusion of the process, the underneath layer contains all the glycerol in watery solution, and the upper layer contains the free fatty acids thus rendered available for soap-making or disposal otherwise. (See "Zinc Formosul.")

According to one account, 75 c.c. of concentrated sulphuric acid and a mixture of 50 grms. fat acids from rape oil, with 17 grms. of phenol, is reported to give good results as a "Twitchell" reagent.

In comparative tests made by O. Steiner, the "contact" reagent, the "Pfeilring" reagent, and a reagent prepared from lignite tar

FATS (*Continued*)—

hydrocarbons for the hydrolysis of fats and oils, a mixture of 100 grms. pure linseed oil, 0·5 grm. of reagent, enough sulphuric acid to yield 0·2 grm. of H_2SO_4, and 50 grms. of water, were boiled under a reflux condenser. After fifteen hours the effected hydrolysis was respectively 85·9, 85·5, 76·7, and 77·2 per cent. with the "contact," "lignite tar," "Twitchell," and "Pfeilring" reagents respectively. 1 : 4 chlorotetralin-sulphonic acid has recently been described as possessing remarkable fat-splitting power.

It is now known that a wide range of substances possess fat-splitting properties, but it appears essential they should be strongly acidic, well sulphonated, and soluble in both fat and water (Rayner).

(See Steger and Schiffers (*Ind. Chem.*, 1927, iii., 327); A. Rayner (*C.T.J.*, 1928, **83**, 182 and 205); K. Nishizawa (*B.C.A.*, 1929, B, 946; 1930, B, 870; and 1931, B, 399).)

The autoclave process of hydrolysis consists in exposing the charge of oil in an autoclave to steam from a high-pressure boiler in presence of a certain percentage (about 2½) of lime or magnesia at 8 atmospheres pressure, thus splitting up the fats directly into fatty acids and glycerol. Resort is made to this process in order to improve the dark colour of fatty acids obtained by splitting processes, and to effect their separation into solid and liquid fractions. The higher the iodine values of the products, the greater is the amount of solid isomerides of oleic acid formed, and the greater the percentage of pitch left behind.

All fats and oils contain more or less acids more unsaturated than oleic, which leads to the production during distillation of *iso*-oleic acid, and the more of this there is in the product, the more greasy is the stearine obtained.

The candle-maker requires a distillate which is crystalline when cold, and the adulteration of tallow with wool fat gives a distillate which crystallizes imperfectly, and so will not press satisfactorily.

Cold-pressed stearines of 100 per cent. free fatty acids are produced commercially.

Attempts have been made to produce edible fats from certain alcohols, and using isopropyl alcohol esterified with stearic acid, a good yield of isopropyl stearic ester can be obtained of m.p. 24° C., said to be of a mild flavour suitable for use as an edible fat. Churned with tallow and milk it makes, so it is stated, a margarine useful for pastry-making.

When heated to from 250° to 300° C., fats and oils are decomposed, acrolein being among the products.

Acetyl Value of Fats (**Acet. v.**)—This shows the amount of oxyacids present, and is represented by the number of milligrammes potassium hydroxide required to neutralize the acetic acid resulting from the hydrolysis of 1 grm. of acetylated fat or wax. A published formula is as follows:

$$A = \frac{S' - S}{1 - 0{\cdot}00075\,S}$$

where S is the neutral hydrolysis value before acetylation and S′ the

FATS (*Continued*)—

value after acetylation. A simple and rapid method of determination is given by E. André (*J.S.C.I.*, 1925, **44**, B. 290); see also *J.C.S. Abs.*, **128**, II., 446.

"Acid Value" (Acid v.) of Fats—This is the number of milligrammes of potassium hydroxide required to neutralize the free fatty acids contained in 1 gramme.

Iodine Value (i. v.) (Hübl Number) of Oils and Fats—This determination, as commonly performed on samples of oils, fats, and waxes, is used to indicate the degree of unsaturation of the compound—that is, the number of pairs of carbon atoms in which two (or in some cases three) valency bonds are concentrated between the two carbon atoms.

Any such double (or treble) linkage is in a state of strain, and when the substance containing it comes in contact with certain other substances (*e.g.*, the halogens), one of the bonds breaks and two atoms of the new substance are attached, one to each of the carbon atoms originally joined by the double linkage.

Thus, every two atoms of the reagent absorbed represent one double linkage in the original substance. The saturated fatty acids have no iodine value.

The reagent used in the Hübl or Wijs method—a modification of the Hübl process—is iodine monochloride (ICl), which adds on one atom of iodine to the one carbon atom, and one atom of chlorine to the other. Thus in this case, *one* atom of iodine absorbed indicates the presence of one double linkage.

The method of Hübl is to make up an iodine monochloride solution from iodine and mercuric chloride, and add excess of this to a known weight of the fat or oil dissolved in chloroform. After standing for some time, the excess of iodine chloride is estimated by the potassium iodide and thiosulphate method; a blank test is carried out alongside, using an equal quantity of the reagent without the substance, and the difference indicates the amount of iodine absorbed by the substance. In Wijs' method an acetic acid solution of iodine chloride is employed. (See J. J. A. Wijs (*Analyst*, 1929, **54**, 12) and *M.* Yasuda (*Ibid.*, 1932, **57**, 182).)

The iodine value may be defined as the amount of iodine chloride absorbed by 100 grms. of the substance expressed in terms of iodine, and is a measure of the proportion of unsaturated fatty acids which in their free state or combined with glycerol assimilate the halogens, and thus form saturated compounds. (See also Hanus Reagent.)

Another method of determining the iodine number is based upon the use of pyridine sulphate and bromine. (See *J.S.C.I.*, 1925, **44**, B, 728.)

The iodine value does not invariably give a satisfactory measure of the relative value of fatty oils for practical purposes, differences being observable, for example, in the case of unsaturated fatty acids (A. Eibner, *B.C.A.*, 1926, B, 201), and L. A. Jordan doubts the validity of the iodine test as the sole criterion of quality for drying oils and thinks the true degree of unsaturation of oils could possibly be best obtained by hydrogenation.

FATS (*Continued*)—

The drying properties of oils are in almost direct ratio of their iodine values. Saturated substances such as the paraffins have iodine value nil.

Iodine-Bromine Number—See L. W. Winkler (*J.C.S. Abs.*, **128,** II., 446).

Reichert-Wollny (**Reichert-Meissl**) **Fat Values**—The values of the soluble, volatile, fatty acids contained in fats, represented by the amount of alkali—that is, the number of cubic centimetres of $\frac{N}{10}$ potassium hydroxide solution (or $\frac{N}{10}$ barium hydroxide solution)—required to neutralize them, as obtained from 5 grammes of fat by saponification with alcoholic sodium hydroxide, evaporation of the alcohol, treatment of the residue with dilute sulphuric acid, followed by distillation and titration of the distillate. (See Elsdon, Taylor, and Smith (*Analyst,* 1931, **56,** 515).)

The Saponification Value (**sap. v.**) (number) of fats and oils indicates the number of milligrammes of potassium hydroxide required for the complete saponification of 1 gramme of an oil or fat. The presence of free fatty acids increases both their saponification and iodine values.

The Polenski (**or Polenské**) **Value** is the difference in temperature between the melting and solidification points of fats.

The Ester Number depends upon the amount of alkali required to saponify the contained esters in fats and waxes, and is equal to the saponification number and the acid number.

The Hehner Value (of fats, oils, and waxes) represents the percentage of insoluble fatty acids + the non-saponifiable constituents.

Fat Extraction—See Simon plant method (*C.T.J.*, 1926, **79,** 161).

The refractivity of oils and fats is ordinarily determined by use of the Abbé-Zeiss or Fery instrument, using sodium light at 20° C.

As a general statement, rancidity in fats and oils may be said to result from chemical changes brought about by micro-organisms or their enzymes in the presence of air, light, and moisture. It is regarded by some as resulting from bacterial action on the glycerides, but by others as due, in the first place, to the formation of superoxides of the unsaturated glycerides and their subsequent decomposition (attended with the production of aldehydes and aldo-acids). In presence of air or oxygen, metals accelerate rancidity in lard, maize, and cotton-seed oils, and light is essential, or at least greatly promotes the process of rancidity in oils and fats so exposed. Slight hydrogenation improves the quality of lard, etc., by increasing the resistance to attack by oxygen (*Chem. and Ind.*, 1932, **51,** 148). The appearance of moulds is accompanied by a marked increase in free fatty acidity, and it seems probable that the presence of free oleic acid is an active factor in rancidity, acrolein decomposition products being always found in fully rancid oils. In general, rancidity is accompanied by a fall in sp. gr., increase in "Reichert-Meissl," "Polenské," and acid values, and a decrease in i. v.

References: "Oils which have been air-blown or have become rancid

FATS (*Continued*)—

at fairly moderate temperatures contain peroxides which are readily reduced by hydriodic acid" (Taffel and Revis, *J.S.C.I.*, 1931, **50,** 91 T); Grettie and Newton (*Analyst*, 1931, **56,** 749); "Fatty Acids and Glycerides of Solid Seed Fats," by Hilditch and Saletore (*J.S.C.I.*, 1931, **50,** 468 T); "Fatty Acids of some Edible Fats," by J. Grossfeld (*Analyst*, 1932, **57,** 112); "Rancidity Changes," by C. R. Barnicoat (*J.S.C.I.*, 1931, **50,** 361 T); Fat-splitting by the autoclave process and fat distillation: *C.T.J.*, 1925, **77,** 418; C. H. Keutgen (*Ibid.*, 1927, **80,** 173); J. G. Vail (*Ibid.*, 1924, **75,** 215); A. Rayner (*Ibid.*, 1928, **83,** 182, 205, and 289); G. F. Pickering (*J.S.C.I.*, 1925, **44,** 424 T); "Nature and Origin of some Natural Fats," E. F. Armstrong (*C.T.J.*, 1924, **75,** 37); "Fat of Sow's Milk," by O. Laxa (*Analyst*, 1931, **56,** 321); "Bearings of Structure on the Utilization of Fats," T. P. Hilditch (*Chem. and Ind.*, 1930, **49,** 210); "Preservation of Fats," G. W. Fiero (*B.C.A.*, 1930, B, 466); "Antioxidants," by Tanka and Nakamura (*B.C.A.*, 1930, B, 776); "Rancidity," by W. L. Davies (*Ind. Chem.*, 1928, iv., 269, and *J.S.C.I.*, 1928, **47,** 185 T); "Degradation of Fatty Acids by Mould Fungi," by Stent and others (*J.C.S.*, 1929, p. 1987); "Differential Hydrogen Absorption of Oils and Fats," by J. W. Croxford (*Analyst*, 1929, **54,** 445); *Industrial Chemistry of Fats and Waxes*, by T. P. Hilditch (Baillière, Tindall and Cox); *Fats: Natural and Synthetic*, by Myddleton and Barry (E. Benn, Ltd.); also Glycerol, Hydrogenation, Margarine, Oils, Soaps, Tallow, Waxes.

FATTY ACIDS—See Acids and Fats.

"FECULOSE" is an acetylated starchy product produced by treating dry starch with glacial acetic acid at 120° C., using, if desired, small additions of mineral acids or formic acid as accelerators. It differs from starch in properties, in that, upon heating with water, it gives a clear stable solution which sets to a soft, translucent, gelatinous mass, forming an excellent substitute for gelatine and gums, and is used as a dressing in the textile industry, and for sizing paper.

FEEDING STUFFS, as used by farmers, depend for their value upon certain digestible constituents, such as oil or fat, albuminoids, carbohydrates, and mineral salts, the unassimilable parts having only, when used as manure, a certain fertilizing value. The heat value of one part fat is about equal to that of 2·4 parts starch or 2·5 parts sugar, but the muscular system of animals is only sustainable by the nitrogenous or albuminoid constituents of foodstuffs, and these are calculated by multiplying the nitrogen constituent by 6·25. The mineral constituents—mainly phosphates of potash and calcium—are also essential items of food. The vitamin principles of vegetables and fruits are doubtless of corresponding value to animals as to human beings. Home-grown crops, such as pasture grass, hay, straw, swedes, and mangolds, form the basis of all foods, but have to be supplemented by the use of more concentrated food, such as linseed, cotton, rape, and other seed cakes, maize, beans, bran, oats, and barley.

The following analytical figures are abstracted, by permission, from

FEEDING STUFFS (*Continued*)—

a paper by Alfred Smetham and F. Robertson Dodd, published in the Royal Lancashire Agricultural Society's annual journal for 1921:

	Water.	Oil.	Albuminoids or Proteins.	Digestible Carbohydrates.	Woody Fibre.	Mineral Matter.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Meadow grass	70·48	0·83	2·95	14·14	9·54	2·06
Meadow hay	14·30	1·48	9·32	41·28	26·83	6·79
Wheat straw	13·81	1·47	2·96	30·29	47·07	4·40
Swedes	90·42	0·20	0·91	6·61	1·29	0·57
Mangolds	87·89	0·17	1·32	8·63	1·06	0·93
Linseed cake, according to variety, from	9·25–12	6–13	28–37	27–41	6–14	5–7
Cotton-seed cake, according to variety, from	9–11	13–24	18–22	22–31	17–27	3·5–5
Maize, according to variety, from	12–17	4–5	9–10	66–70	1–2	1¼–1¾
Beans (English)	14·14	1·86	28·12	46·70	6·14	3·04
Bran	11·45	4·33	16·46	57·00	6·50	4·25
Oats (crushed)	13·45	6·77	11·12	56·92	9·14	2·60
Barley (grain)	14·95	1·46	8·59	67·96	4·46	2·58

The water content of feeding stuffs has no feeding value.

In a later communication, Messrs. Smetham and Dodd give tables showing the standard rations required per day for every 1,000 lbs. of live weight of cattle and the calculated "food units" of many cereals and by-products, these values being calculated on the assumption that oil and albuminoids are of equal value and together are 2½ times as valuable as the carbohydrates (same journal, 1928).

In a lecture by G. H. Ayers, the "digestible food units" of certain products, calculated upon the albuminoid matter, the oil and fat, and the carbohydrate constituents, have been given as follows:

Meat meal	190–204	Distillers' grains (dried) ..	101
Bone and meat meal ..	140–165	Palm-kernel cake	96
Bone meal	95–105	Wheat sharps	90·5
Dried blood	190–204	Maize meal	86·5
Swill or plate leavings ..	120–134	Brewers' grains (dried) ..	84·5
Fish meal	150–170	Barley	83
Ground-nut cake ..	145	Wheat bran	77·5
Decorticated cotton-cake	126	English oats	75·4
Soya-bean cake	122	Malt culms	69·9
Linseed cake	120		

In a process devised by F. Bergius for the utilization of wood in the preparation of a cattle-feed stock, the cellulose is converted into a kind of sugar by use of hydrochloric acid in a special manner, and this, mixed with dried potato flakes, is said to provide a suitable feed-stock to which protein can be added in the form of soya-bean meal or oil cake. (See *C.T.J.*, 1930, **86,** 290; Bone-Black, Ensilage, Oil Cakes, and Vitamins.)

FEHLING'S SOLUTION—A solution of cupric sulphate mixed with Rochelle salt (a double tartrate of potassium and sodium) and alkali, used as an oxidizing agent, and employed as a test for the determination of inverted sugars or other reducing agents in solution, by ascertaining the amount of cuprous oxide produced by its action. An article on its preparation, by J. H. Lane and L. Eynon, is given in *J.S.C.I.*, 1925, **44**, 150 T. Sugar itself does not reduce Fehling's solution, and requires to be first of all inverted. A strength recommended by one writer is that of which 10 c.c. are equivalent to 0·05 grm. of dextrose (G. Pégurier, *J.S.C.I.*, 1925, **44**, B, 1004).

FELSPARS (**Feldspars**) (Crystal systems, Nos. 5 and 6)—Various compound mineral silicates of aluminium and other metals, found abundantly in nature, and widely distributed, including many large deposits in Cornwall, Ireland, Wales, and Scotland, as much as 14 per cent. potassium oxide (K_2O) being obtainable from some small veins of *orthoclase* or *potash felspar* ($K_2O,Al_2O_3,6SiO_2$), although most of them are not suitable for potash extraction. The silicon content varies in the more important sorts from 43 to about 69 per cent. Felspars are used in the enamel, glass, pottery, and porcelain manufactures. (See "Chemistry of the Felspars," by D. Beliankin (*B.C.A.*, 1930, A, 57); also Clays, Basalt, Porcelain, and Potassium.)

FELT—Wool or hair worked into sheet form by matting. (See Fibres and Hair.)

FENCHENE—A terpene ($C_{10}H_{16}$).

FENCHONE—A ketone ($C_{10}H_{16}O$) constituent of thuja oil and fennel-seed oil.

FENNEL-SEED OIL—A colourless, aromatic oil from the fruit of the common fennel (*Anethum fœniculum*—a genus of umbelliferous plants), identical to some extent with oil of aniseed. It contains 50 to 60 per cent. anethol, 10 to 20 per cent. *d*-fenchone (a ketonic body, $C_{10}H_{16}O$), and some pinene and dipinene; is soluble in alcohol, ether, etc., and used in perfumery and in making liqueurs. (See note on its components, *B.C.A.*, 1929, B, 910.) The yield is from 4·5 to 6·5 per cent.

The sp. gr. is said to vary from 0·884 to 0·974 at 15° C., the opt. rot. from $+6°$ to $+24°$ at 20° C., and the ref. ind. from 1·4756 to 1·5335, according to the kind and mode of preparation. The herb is cultivated in many European countries, India, Japan, and Persia; while the Saxony and Galician varieties yield most oil (about 4 to 6 per cent.), and the East Indian variety (*Fœniculum panmorium*) only about 2·2 per cent. (Compare Rutovski, *B.C.A.*, 1928, B, 768.)

FENUGREEK (*Fœnum Græcum*), a genus of Leguminosæ—The seeds of *Trigonella* (Egypt, S. Europe, Asia Minor, etc.), used in compounding medicines, veterinary preparations, etc. It is largely cultivated in India as a fodder plant.

FERGUSONITE—A mineral represented as $Y(Nb,Ta)O_4$, of crystal system, No. 2, and sp. gr. 5·8, with which uranium is also found in association.

FERMENTATIONS—Chemical changes brought about by yeast and other forms of cell life (including bacteria and various fungi) in suitable media,

FERMENTATIONS (*Continued*)—

but directly due to enzymes, which are produced by or contained in the living cells. The act of fermentation is generally accompanied with liberation of gas (effervescence) and the evolution of heat.

Yeast cells (*saccharomyces*), for example, and an extract prepared from them but free from the living cells, contain zymase, an enzyme which breaks up certain sugars to the extent of about 95 per cent. into alcohol and carbon dioxide: $C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$. A medicinal preparation known as "*zymine*" is made by the extraction of moist yeast cells with acetone, and, while it is quite incapable of growth or reproduction, it is much more active in inducing fermentation than they are. The most favourable temperature for fermentation is from 25° to 30° C., and living yeast cells are killed when the alcoholic strength of the product reaches about 14 per cent.

The lactic fermentation or souring of milk is induced by a bacterium known as the *Bacterium lactis,* but if a mixed fermentative agent is employed, such as old cheese, which contains many kinds of ferment, the lactic acid first of all produced is changed into butyric acid.

In the butyric fermentation of starch or sugar induced by the *Bacillus butyricus,* butyric acid ($C_4H_8O_2$) is produced.

The change of alcohol into acetic acid experienced in the souring of light wines or beer, is another act of fermentation due to enzymes. The fermentation of starch by the action of *Clostridium acetobutylicum* (Weizmann), which normally produces butyl alcohol, acetone and ethyl alcohol in a fixed ratio, is referred to under the heading of Acetone; see also *C.T.J.*, 1927, **80,** 83. This is an illustration of the possibility of modifying the ratio of the products by alteration of the conditions of nutrition of organisms. In industries dependent upon processes of fermentation, great care has to be taken in the preparation of pure cultures of the organisms required, so as to avoid the formation of undesirable products which might result from the action of foreign or pathogenic organisms, thus reducing the yield and imparting damaging qualities.

References: A survey of fermentation processes in connection with the making of bread, tea, coffee, cocoa, sauerkraut, pickles, vinegar, sauces, cheeses, etc., by F. C. Black (*Ind. Eng. Chem.*, 1930, **22,** 1166); article on "Fermentation Phenomena," by T. K. Walker (*Chem. and Ind.*, 1930, **49,** 946); reference to utilization of carbon dioxide resulting from fermentation process (p. 146); "Some Fermentative Changes of Technical Interest," by F. Challenger (*Ind. Chem.*, 1930, vi., 97); "Alcoholic Fermentation," by F. Challenger (*Ind. Chem.*, 1929, v., 239); "Simple Universal Thermostat for Fermentation Laboratories," by H. Fink (*B.C.A.*, 1931, B, 39); "Recent Advances in the Fermentation Industries," by J. V. Eyre (Lecture, Inst. of Chem., November, 1931); *Micro-organisms and Fermentation,* by A. Jörgensen (C. Griffin and Co., Ltd); *The Problem of Fermentation*, by M. Schoen, translated by H. L. Hind (Chapman and Hall, Ltd.); also Acetic Acid, Acetone, Beer, Enzymes, Methane, Wine, and Yeasts.

FERRATES—Compounds corresponding to the manganates, of which potassium ferrate (K_2FeO_4) is illustrative.

FERRIC SALTS—See Iron Compounds.

FERRICYANIDES—See Cyanogen.

FERRITES—Compounds of ferric oxide with other more basic oxides—for example, zinc ferrite (Fe_2O_3,ZnO).

FERRO-ALLOYS—See Iron.

FERRO-CERIUM (Pyrophoric Alloys)—See Iron and Pyrophoric Alloys.

"FERROCRETE"—See Cement.

FERROCYANIDES—See Cyanogen.

"FERRO-PRUSSIATE"—Trade name for potassium ferrocyanide.

FERRO-SILICON—See Iron.

FERROUS METALS—See Iron.

FERROUS SALTS—See Iron.

FERRUGINOUS—Containing iron. Many natural mineral waters are ferruginous in character and act as tonics. (See Chalybeate Waters.)

FERTILIZERS are materials containing as three principal constituents, nitrogen, potassium, and phosphorus, for application to the soil to assist or promote the growth of vegetable life, and as the well-being of plants depends upon an adequate supply of the various constituents found in them and necessary to their existence and full development, they cover a very wide field and vary accordingly with regard both to the nature of the soil and the character of the plants. The initial effect of fertilizers is increase of the required nutrient in the plant tissues, but excessive quantities are likely to cause danger of sorts which may call for correction by other treatment.

They include Peruvian guano (the dried excrement of sea-birds), nitro-lime, stable manure, cow-dung, slaughter-house refuse, blood, bones; ammonium sulphate, nitrate, and chloride; coprolites, rock phosphates, superphosphate, basic slag, fish meal, fish offal, potash salts, Chile nitre, oil-seed cakes, burnt lime, marl, clay, sulphur, sea-weed, gypsum, calcium nitrate, urea, etc. It has been shown that straw is able to assimilate the nitrogenous constituents of urine, sewage, etc., and as thus prepared constitutes a valuable manure. Straw alone, wetted by a spray of water and allowed to ferment, is a good fertilizer, provided suitable bacteria are present. Many of these materials are described under their several names.

The material known as "tankage" in the United States is derived from meat scraps, carcasses, bones, intestines of animals, etc., cooked in specially constructed tanks, and after removal of the fat, passed through a filter-press, dried, and then ground. It is a meal of brownish colour, containing from about 7·5 to 9 per cent. nitrogen and 12 to 20 per cent. tricalcium phosphate.

Dried fish scrap made from *menhaden* (moss-bunker fish) usually contains from 7 to 9 per cent. nitrogen and 14 to 16 per cent. tricalcium phosphate.

FERTILIZERS *(Continued)*—

Cotton-seed meal is used to some extent as a fertilizer, and contains from 4 to 8 per cent. nitrogen, about 2·88 per cent. phosphoric acid, and about 1·77 per cent. potash.

Ammonium sulphate as produced in gasworks contains about 24½ per cent. of ammonia, and in 1914 the total production of the United Kingdom was 426,000 tons. There is little to choose between the values of this substance and nitre, but it is stated that ammonium nitrate is more effective than ammonium sulphate for the growth of mangolds and wheat, and constitutes the most effective and valuable nitrogenous fertilizer.

An exchange of bases occurs when ammonium sulphate is applied to soil; lime, magnesia, potash, and soda dissolving in the soil water of the surface and the ammonia becoming attached to the surface soil.

Methods for the manufacture of ammonium phosphates for use as fertilizing agents are outlined by Ross, Merz, and Jacob (*Ind. Eng. Chem.*, March, 1929).

Nitrate of calcium usually proves as effective as soda-nitre, but is apt to turn sticky in a moist atmosphere; it is of special value in heavy soils and those deficient in lime.

The hygroscopic character of ammonium nitrate militates against its use, but a process which produces it in the form of rounded grains instead of the usual crystals overcomes this objection to some extent.

"Phosphazote" is a fertilizer, being a complex compound of urea and mono-calcic phosphate, and the treatment of acid phosphate with ammonia is spreading in the U.S.A.

Crude gas liquor at about 3° Baumé, containing 1·5 per cent. ammonia or 1·23 per cent. nitrogen, is used to some extent, particularly in Germany, as a fertilizing agent, and is said to give results quite equal to those obtained from ordinary manure, besides which it has destructive action on weeds. It can be used at any season, of the strength of from 1° to 3° B. according to the state of the land, the higher strengths being employed when the land is lying fallow, and can be used alone or mixed with other manure.

"Basic slag" is a valuable fertilizer for grass-lands, capable of producing a fourfold increase in productive power owing to the effect it has on the growth of wild white clover and other leguminous plants, such as bird's foot trefoil or kidney vetch, half a ton to the acre being recommended. In sandy or peaty soils the addition of lime or potash may be necessary. (See Iron (Slag), p. 499.)

The value of fertilizers is determined by the amount of nitrogen, phosphates, and potash they contain, and of these the phosphates are of predominating importance. Upon this view, the phosphates present in certain materials have been appraised as follows:

Condemned meat or carcasses	24 to 25 per cent.
Bone	47 to 48 ,,
Swill	18 to 22 ,,
Fish guano	14 to 20 ,,

FERTILIZERS (*Continued*)—

Although the plant nutrients of farmyard manure can be equally well supplied by other materials, it is believed that the former possesses some advantages not yet fully understood. When used in excess, however, it is liable to produce fungoid disease, such as rust, in cereals. It is possible that the cellulose content of farmyard manure may be of special value in connection with the nitrogen-fixing organisms, and its decomposition products of a humus character may modify the colloidal character of the soil, while it is certain that farmyard manure greatly influences its micro-organic population. (See L. L. Balaschev on the "Use of Stall Manure" (*B.C.A.*, 1930, B, 580).)

Another material which appears to meet the demand for a mixed fertilizer is provided by a process carried out by Mr. E. Lloyd Pease, of Darlington, which consists in using crude phosphoric acid in place of sulphuric acid for fixing the ammonia yielded by coal distillation, the phosphate thus obtained being subsequently mixed with finely ground coke, shale, peat, or clay, the advantage of using peat lying in the fact that it supplies the organic material found in farmyard straw and also contains nitrogen. (See Peat.)

Under the direction of M. Edouard Urbain the production of so-termed "rational fertilizers" at Givors is in progress, whereby phosphorus, potassium, and ammonium are present, and the proportions can be altered to suit varying applications. (See *Ind. Chem.*, 1930, vi., 2.)

Experimental research has shown that, in respect of fruit plants, marginal scorch in the leaves may indicate a deficiency of potash; pronounced bronzing of the foliage a deficiency of phosphate; abundantly large leaves that hang on late, a deficiency of lime; small leaves and poor, hard, tasteless fruit a lack of nitrogen. It has further been shown that it is profitable to adequately fertilize with phosphate and nitrate.

The exigencies of war compelled Germany to erect plants for the fixation of nitrogen from the air, and it has been reported that the whole of the nitrogen compounds required for making explosives and for agricultural use was produced in this way. In this direction our country has now followed suit.

References: H. J. Jones on *Fertilizers and Feeding Stuffs Act*, 1926 (Butterworth and Co.) embodies the official information relative to its provisions; see also Statutory Rules and Orders, etc. (*Analyst*, 1931, **56,** 460); "The Influence of Fertilizers on the Yield and Composition of Plants," subject of a discussion by the Agricultural Section of the British Association Meeting, 1930, as summarized (*C.T.J.*, 1930, **87,** 279); "Non-caking Fertilizer Granules" (*C.T.J.*, 1932, **90,** 229); a survey of recent developments concerning the newer fertilizers, by W. H. Ross (*Ind. Eng. Chem.*, January, 1931); "Fertilizers in their Relation to the Soil," by H. Bassett (*Ind. Chem.*, 1926, ii., 427); *Chemical Fertilizers*, by S. H. Collins (Baillière, Tindall and Cox) and H. Cave (Sir Isaac Pitman and Sons, Ltd.) respectively; and *Artificial Fertilizers*, by Parrish and Ogilvie (Ernest Benn, Ltd.). (See also Bones, Caliche, Coprolites, Cyanamide, Nitrogen Fixation (p. 620),

FERTILIZERS (*Continued*)—

"Nitrophoska," Phosphates, Slag, Straw, "Superam," Superphosphate of Lime, Urea, and Vegetation.)

FESCOL PROCESS—See Electricity, p. 293.

FIBRES—Dealing with fibre from a food point of view, Dr. McChance groups true cellulose, oxycellulose, lignin bodies, and resistant anhydrides of the five carbon sugars together. (See S. Dixon (*Chem. and Ind.*, 1930, **49,** 645 and 663); M. O. Pelton on "Lustre of Textile Fibres and a Method of Measurement" (*B.C.A.*, 1931, **50,** B, 59); W. Garner on "The Microscopical Examination of Fibres" (*Ind. Chem.*, 1929, **5,** 147); J. B. Speakman on "The Denaturation of Wool" (*Chem. and Ind.*, 1930, **49,** 441); W. T. Astbury on "The Inner Structure of Hair" (*Ibid.*); C. A. Mitchell on "Hairs and Fibres" (*Chem. and Ind.*, 1930, **49,** 451); A. Herzog on "Fibrillar Structure of Bast Fibres" (*B.C.A.*, 1932, B, 176); "Hat Manufacture" (*Ind. Chem.*, 1932, viii., 53 and 93); Films and Hair.)

FIBRIN (**Syntonin**)—A constituent of the blood which separates from it upon coagulation (clotting). It is of an albuminoid character, and its composition is approximately as shown:

Carbon	52·7
Hydrogen	6·9
Nitrogen	15·4
Oxygen	23·5
Sulphur	1·2
Phosphorus	0·3
	100·0

It has been conjectured that the clotting of blood is brought about by an enzyme in the blood called thrombose (thrombin), but this has not been definitely determined. This fibrinolytic agent (also named thrombolysin) is stated to exhibit its maximum activity at 37° C. in neutral solution; to be precipitable by alcohol, ammonium sulphate, and zinc chloride and to become inactivated at 46° to 48° C.

FIBROLITE—A trimorphous mineral of similar composition to andalusite.

"FIBROX"—A variety of "siloxican," being a soft, elastic, fibrous material of pale greyish-blue colour. (See "Siloxican.")

FILMS—See H. Levinstein on "Films and Fibres Derived from Cellulose" (*J.S.C.I.*, 1930, **49,** 55 and 77 T); Soap Films (p. 823), Cellulose (p. 160), and Nitro-Cellulose.

"FILTER CELL"—A proprietary infusorial filtering earth agent.

FILTER PRESSES—See Filters.

FILTERS and FILTRATION—Filters or strainers provide the means of separating liquids from solids, the common laboratory form consisting

FILTERS AND FILTRATION (*Continued*)—

of a circular piece of porous paper made of a special quality, which yields a minimum amount of ash when burned (incinerated). By folding it first of all into halves and then into quarters, it will be found, when opened out, to fit into a funnel of appropriate size, the paper lying against the sides of the funnel. In common practice, the paper filter, when so fitted, and before use, is first of all moistened with a liquid of the same nature as that of the mixture to be filtered. Thus, for aqueous mixtures, water is applied from a wash-bottle (which see); for alcoholic mixtures, alcohol of the same strength should be used, and so forth.

Paper filters can, in some cases, be used for separating two liquids of different gravities that are not miscible—that is, cannot be mixed together so that they will not separate again after shaking and upon standing; for example, a mixture of turpentine and water or olive oil and water. In such cases, if the filter be first of all wetted with water and then used, the watery (aqueous) part will pass through the filter-paper, while the oily bodies will be retained more or less permanently on the filter. The porosity of filter-papers can be measured by use of the Herzberg apparatus (see *Ind. Chem.*, 1928, iv., 77).

Whatman's Extraction Thimbles are made of specially prepared filter-paper, are seamless, and can be used repeatedly for the extraction of soaps, fats, foods, rubber, etc.

There are several ultra-filters prepared from ether-solutions of collodion of varying concentration coagulated with benzene or toluene, or that substance in admixture with others, or with gelatine hardened by formaldehyde, which can be made to effect varying degrees of filtration; while J. Manning has described membranes for ultra-filtration prepared by the electrical deposition of nickel on fine nickel gauze, which can be used at high temperatures and in presence of organic solvents (*J.C.S.*, 1926, p. 1127, and R. Wasmuht, *B.C.A.*, 1928, A, 985).

There are filters made of porous glass made by fritting finely powdered and sieved glass; others made from quartz; also filters or strainers of solid porous porcelain or earthenware which are sometimes employed for straining liquids from magmas or thick, moist mixtures of crystalline or other solid substances. These filters sometimes take the form of solid flat plates on which the magma is placed (taking care that it does not overflow the edges of the strainer), the liquid part gradually soaking or flowing away through the texture of the filter-block, leaving the more or less dry crystalline or other solid body on its surface.

In other cases, strainers are constructed of funnels having their necks plugged more or less tightly with various materials known to be chemically unaffected by the materials to be filtered—as, for example, glass-wool, slag-wool, asbestos fibres, cotton-wool, flannel, wood pulp, etc.

The "*Büchner*" *Funnel* is a type of filter designed for the filtration of bulky precipitates, usually made of stout porcelain, and consists of a cylindrical cup of 5 to 15 cms. diameter and 3 to 5 cms. deep. The flat bottom is pierced with a number of holes, and below it the funnel

FILTERS AND FILTRATION (*Continued*)—

narrows rapidly to an outlet tube 1 to 2 cms. in diameter. A circular sheet of filter-paper or other filtering medium is laid down on the perforated bottom so as to cover it completely, and the cup is filled up with the liquid to be filtered, and a porous attachment to take the place of paper is available. (See *Ind. Chem.*, 1926, ii., 282.) It is always used in conjunction with a suction filter-pump. An improved method of using this filter is described by G. Thompson (*Chem. and Ind.*, 1926, **45**, 899).

As a substitute for the "Büchner" funnel, fritted Jena glass filter discs are now available, formed by sintering or fritting glass powdered to specific-sized particles according to requirement, the finer particles being capable of retaining barium sulphate recently precipitated. They can be fused into funnels, thistle tubes, or "Soxhlet" apparatus, and may be used in place of the "Gooch" crucible (*Analyst*, 1925, **50**, 440). The "Shimer" tube filter for finely divided and gelatinous precipitates is described in the *Ind. Eng. Chem.*, March, 1925.

Filter presses are mechanical contrivances of various patterns, consisting essentially of a frame carrying a number of loose slabs of filter surface which can be clamped to form a series of hollow chambers capable of withstanding internal pressure, the filter surface being ribbed or grooved and covered with cloth. These chambers are made of various materials—aluminium, bronze, ebonite, iron, wood, etc.—according to the nature of the materials to be dealt with, some with jacketed plates enabling filtration to be effected at any desired temperature, and others of a rotary character worked *in vacuo*. Regard must of course be had to the kind of cloth and the necessary adaptations according to the chemical and physical qualities of the subject material. According to Hinchley and Clarke (*J.S.C.I.*, 1926, **45**, 1-8 T), the rate of flow of a liquid through a filter cake is assumed to be proportional to the pressure of filtration and inversely proportional to the resistance to flow, which is made up of the initial resistance due to the cloth, press, etc., and that of the cake as it is built up.

The "stream-line filter" described by Hele Shaw consists of a pack of several thousand similar narrow strips of paper or other fabric having a matte surface impervious to the subject liquid, and punched with holes, so packed together as to admit of mechanical pressure. In this way the finest materials, such as bacteria, colloid particles, and other suspended matters, are retained upon entering the films, and upon releasing the pressure the filter can be readily cleansed by driving a washing fluid in either direction, while the precipitate can be removed by allowing the contents of the inlet holes to discharge intermittently or continuously through a suitable orifice. By its use gelatin can be filtered up to a 12 per cent. solution, and the apparatus is also suitable for glue, malt extract, fruit juices, linseed oil, varnishes, etc.

The process may be described as filtering over a surface instead of through a medium, and is available for commercial use in respect not only of water, but such articles as colloidal solutions, dirty paraffin oil and other liquids, the pressure required being dependent upon the

FILTERS AND FILTRATION (*Continued*)—

fineness of filtration and the viscosity of the fluid. For further particulars see J. H. Pickard (*C.T.J.*, 1925, **76,** 71); *Ind. Chem.*, 1925, i., 124; 1927, iii., 67 and 372; J. W. Hinchley (*Chem. and Ind.*, 1926, **45,** 660); and P. F. Jordan and A. C. Marshall (*J.S.C.I.*, 1927, **46,** 304 T).

In manufacturing and industrial operations, centrifugal and other appliances constructed on these several principles, some rotary and some oscillatory in character, and others supplemented by suction when necessary, are extensively employed, particularly where large volumes have to be dealt with, and when it is difficult to otherwise separate liquids from the mixtures to be dealt with, some being water-driven, others electrically driven. Kieselgühr is largely employed as a filtering medium. Woven fabrics are employed industrially, those of high resistance to flow of water being selected; for corrosive liquids, metal, asbestos, and stone being used among others, and for non-corrosive liquids, various materials ranging from the dense "cotton duck" to the unbleached muslin as the other limit. (See J. W. Hinchley (*Ind. Chem.*, 1928, iv., 24); *J.S.C.I.*, 1924, **43,** 975; and *C.T.J.*, 1926, **78,** 73). An enclosed continuous filter for use with vacuum or pressure is described in the *Ind. Chem.*, 1926, ii., 186.

In practice, some preliminary filtration has often to be made before the clouded filtrate thus prepared can be more perfectly filtered.

"Ultrafiltration" implies the straining off of very finely divided particles or colloidal suspensions from liquids by forcing them through the walls of semi-permeable membranes. (See E. J. Lush (*Ind. Chem.*, 1929, v., 225); and H. Bechhold (with others) on "Size of Pores of Ultra-filters" (*B.C.A.*, 1931, A, 795).)

"Metafiltration" is a term given to the type of filtration as effected by "Metafilters," which are claimed to give the fineness obtained by use of an ultrafilter with the rapidity of cloth, and are constructed of perforated strips of special character, giving a coarse filtration coupled with fine filtration of a combined filter bed. (See J. A. Pickard (*Ind. Chem.*, 1929, iv., 505, and *Chem. and Ind.*, 1930, **49,** 33).) Various metals, alloys, celluloid, vulcanite, etc., have been employed in their construction, and in order to overcome certain difficulties encountered in the use of earlier types Mr. Pickard has designed some special constructions described in a later paper (*J.S.C.I.*, 1930, **49,** 259 T).

A newly patented rotary pressure filter (A. R. Jahn, English patent 339,669) is illustrated in the *C.T.J.*, 1931, **88,** 158.

Two U.S.A. vacuum filters of recent design are known respectively as the "Joubert and Goslin" and the "Dorrco" internal drum filter.

Sand is used in waterworks for the filtration of water on a large scale, and there are many types of domestic filters variously prepared for the purification of water. In some, animal charcoal pressed into blocks is used, and no doubt it assists the oxidation of organic matters but does not sterilize the water.

In the "Chamberland-Pasteur" filter a cylinder of unglazed porcelain, and in the "Berkefeld" filter a block of baked siliceous earth (kieselgühr) is employed. Both of these remove the micro-organisms

FILTERS AND FILTRATION (*Continued*)—

from the water, but they require periodical sterilization. In the "Bischof" filter, iron in a spongy form proves useful in many circumstances.

Other References: "Modern Filtration Plant," by H. J. Runyon (*C.T.J.*, 1927, **80**, 261); "Studies in Filtration," by Clarke, Ure, and Hinchley (*C.T.J.*, 1925, **77**, 131 and 169; *J.S.C.I.*, 1926, **45**, 1 T); "The Mechanical Basis of Filtration," by J. A. Pickard (*Ind. Chem.*, 1928, iv., 186); "Filtration Equations for Compressible Sludges," by A. J. V. Underwood (*J.S.C.I.*, 1928, **47**, 325 T); "The Mathematical Theory of Filtration," by A. J. V. Underwood (*Ind. Chem.*, 1928, iv., 463); "Studies in Filtration," by Van Gilse, Van Ginnekin, and Waterman (*J.S.C.I.*, 1930, **49**, 444 T; *Ibid.*, 1930, **50**, 483 T, and 1931, **50**, 41, 96 T); "Air Filtration in a Food Factory," by S. Lancefield (*Ind. Chem.*, 1930, vi., 452); "New Developments in Filter Papers," by E. J. Guild (*Analyst*, 1931, **56**, 652); *Filtration and Filters*, J. A. Pickard (E. Benn, Ltd.); Celite, Gooch-Crucible, Kieselgühr, Supercel, Water (Sand Filtration).

"FILTROL"—A decolourizing material, consisting of silica and about 7 per cent. of aluminium silicate, ground to pass a 200-mesh sieve, and stated to have three or more times the efficiency of standard fuller's earth.

FIR-SEED OIL, from the seeds of *Pinus abies* (L.) and allied species; used in making paints and varnishes, and reported to have a sp. gr. of 0·9295 at 15° C., solidifying-point of −26° C., sap. v. 191·8, i.v. (Hanus) 154, and to contain 91·6 per cent. non-volatile fatty acids, composed of 0·7 per cent. palmitic acid and 99·3 per cent. unsaturated acids (oleic, linolic, and linolenic). Oil of this name must, however, vary considerably in properties according to its source. Seeds from *Pinus sylvestris* L. yield an oil of sp. gr. 0·9307, solidifying at −30° C., sap. v. 190·7, i.v. (Hanus) 159·2, containing 9·7 per cent. liquid acids (oleic, linolic, and linolenic), together with 3 per cent. solid fatty acids (palmitic and stearic).

FIRE—See Armstrong (H. E.) on "The Mechanics of Fire" (*J.S.C.I.*, 1905, p. 473); chemical types of fire-extinguishers, by W. R. Ormondy (*C.T.J.*, 1927, **80**, 479); "Chemical Works Fires," by R. D. Owen (*Chem. and Ind.*, 1931, **50**, 384); E. Biesalski (*B.C.A.*, 1930, B, 744); "Lux" system (*Ind. Chem.*, 1928, iv., 379); "Fire Risks in Industry," by A. Cameron (Inst. of Chemistry publication), and book by S. G. Gamble (C. Griffin and Co.).

FIRE-CLAY—See Clays, Porcelain, and Refractories.

FIRE-DAMP—An explosive gas naturally produced in coal-mines, and chiefly composed of methane (marsh gas, CH_4) admixed with air, nitrogen, and some carbon dioxide. For limits of inflammability of mixtures of methane, air, nitrogen, and carbon dioxide, see H. F. Coward and F. J. Hartwell (*B.C.A.*, 1926, B, 426); and Flame.

FIRE-PROOFING—Some of the chemicals used are employed because they fuse below the ignition point of the fabric, forming a non-inflam-

FIRE-PROOFING (*Continued*)—

mable layer on the surface; others, because at temperatures below the ignition point they decompose and evolve gases incapable of combustion, such as steam, carbon dioxide, and ammonia; a third class because they absorb by endothermic changes, including volatilization, the heat of flame, and so forth.

Ammonium salts are of some value for the fire-proofing of wood, the phosphate being probably the best, as on heating it gives off ammonia which is incombustible and leaves phosphoric acid, which melts and covers the fibres of the wood. Borax is not so good, but more economical. Among other salts claimed to be of use are potassium silicate, alum and borax in mixed solution, common salt, strong solutions of the alkalies and alkaline earths, and the chlorides of calcium, zinz, and mercury. A paint known as "Calcimine," has been found satisfactory for inside purposes, whilst for outside applications a coating of zinc borate and chrome green ground in linseed oil exhibits good fire-resisting properties.

A fire-proofing mixture for wood and thatch, as prepared from a Home Office formula, is made by dissolving 28 lbs. ammonium sulphate, 14 lbs. ammonium carbonate, 7 lbs. lump borax, 7 lbs. boracic acid, and 14 lbs. lump alum in 500 lbs. (50 gallons) water.

For use in connection with fabrics, the effects of the chemicals and associated treatment upon the fabrics have first to be considered, some having a tendering effect and others causing deterioration of quality or encouraging the growth of micro-organisms. It must also be borne in mind that after treatment they will probably be exposed to rain or water, ruling out of use many soluble agents. (See *C.T.J.*, 1930, **86**, 426.) The fire-proofing of flannelettes is described in a paper by C. H. Butcher (*C.T.J.*, 1930, **87**, 634).

FIREWORKS (**Pyrotechny**) are luminous devices made from combustible or explosive chemicals, largely dependent upon the use of gunpowder, metallic filings being introduced to produce scintillation, and many chemicals being used in association to produce colouring and other effects. (See Flame Coloration.)

FIRST AID in Chemical Works—See Safety (Industrial).

FIRST RUNNINGS, resulting from tar distillation, is the fraction up to 105° to 110° C., containing water, ammonia, and some light oil.

FISH GLUE—See Glue and Isinglass.

FISHING-NET PRESERVATION—See *C.T.J.*, 1930, **87**, 377.

FISH OILS are of the non-drying class, and usually have an offensive odour, which, however, is removed in the chemical changes brought about by their hydrogenation. (See Hydrogenation, p. 461.)

The commercial fish oils are in the main devoid of the liver oils (the livers, when of value, being first of all removed), and are obtained from all parts of the common fish, such as herring, sardine, salmon, sprat, etc., by boiling the fish in a tank with a perforated grid to support the fish, during which operation the oil rises to the surface and is then

FISH OILS (*Continued*)—

removed, being a high-grade oil of pale colour. The dried fish residue is subsequently extracted with benzene, by which a dark oil is obtained which requires refining. Cod-fish contains only 1·8 per cent. oil and ling 2·2 per cent., so that they are not rich enough in oil to be treated by this process. Blubber oils are obtained from the whale, seal, and turtle by boiling the blubber after removal from the fish. Fish oils upon standing in the cold are subject to the deposition of stearin.

Cod-Liver Oil is obtained by steam-heating in jacketed pans or blowing the steam direct into the livers of various species of Gadus, and especially from the torsk (*Brosimus brosme*). Large quantities are imported from Norway and Newfoundland, a proportion of the stearin contained therein being first of all removed by cooling; in the case of Norwegian oil, the amount removed is from 3 to 5 per cent. The oil has a sp. gr. of from 0·92 to 0·93, sap. v. 187 to 197·5, i.v. 150 to 181, ref. ind. 1·479 to 1·483, acid v. about 2·5, and solidifies at 0° to −10° C. It is stated to contain (in addition to palmitic, myristic, and stearic acids) zoomaric acid ($C_{16}H_{30}O_2$), which is said to be a constituent of the oils and fats of most marine animals. Some further analytical aspects of average Newfoundland cod-liver oil are given by A. E. Briod and others (*B.C.A.*, 1929, B, 861).

The oil is largely used as a nutritive food, also in medicine and for leather-dressing. Its therapeutic value would appear to depend upon its ready digestibility, absorbability, and its vitaminic character, which latter is liable to depreciate by any oxidative change to which it may be exposed. Takahashi claims to have separated from this oil a substance ("Biosterm") of formula $C_{27}H_{46}O_2$ having the properties of vitamin A. See Jaha, Hilditch, and Lovern (*Biochem. J.*, 1930, **24,** 266); Drummond and Hilditch on "The Relative Values of Cod-Liver Oils from Various Sources" (H.M. Stationery Office, E.M.B., 35, December, 1930); Cholesterol and Vitamins.

Dugong Oil (**Manatee Oil**), from the blubber of the sea cow (*Halicore indicus*); sp. gr. 0·9242 at 15° C., sap. v. 204·7, i.v. 52·5 (Hübl), acid v. 0·3, r.p. at 40° C. −0·12°; used to replace cod and whale oils and for burning (in India.)

Herring Oil is yellowish-red, with a sp. gr. about 0·92, sap. v. 180 to 194, i.v. 120 to 142, ref. ind. 1·480 at 15° C., acid v. 6·53. It is soluble in carbon disulphide, benzene, and ether, and contains about 19 per cent. saturated acids, including palmitic and myristic acids, the bulk consisting of acids of the oleic series. It is used in making printing-ink, soap, leather-dressing, and the steel industry, while the meal is a useful food for poultry and animals.

Menhaden Oil—A yellowish-red oil extracted from the menhaden or moss-bunker fish, having a solidifying-point of −4° C., sp. gr. 0·927 to 0·933, sap. v. of 191 to 196, and i.v. 142 to 180. It is soluble in ether, naphtha, carbon disulphide, and benzol, and is used in rope and leather-dressing, paint and varnish making (in combination with or substitution for linseed oil), etc.

FISH OILS (*Continued*)—

Pilchard Oil—Resembles herring oil in general respects, and is yielded by pressure from the pickled fish (*Clupea pilchardus*, a member of the herring family) to extent of from 1½ to 2½ gallons per 100 kg. It is of a pale yellowish-brown colour, with little objectionable odour, and deposits stearin on long standing; contains 8·15 to 9·32 per cent. free fatty acids calculated as oleic acid, is of sp. gr. 0·9328 to 0·9313 at 15·5°/15·5°, sap. v. 186 to 189·6, i.v. (Wijs) 170·4 to 172·7, ref. ind. (D. line) at 40° C. 1·4751 to 1·47425, and makes a good pale, amber-coloured potash soft soap. (See *C.T.J.*, 1930, **87**, 297.)

Porpoise Oil is extracted from the brown porpoise, and is of pale yellow colour, sp. gr. about 0·926, sap. v. 195 to 256, and i.v. (varying with the part of the body yielding same) from 88 to 119. It is soluble in ether, chloroform, carbon disulphide, and benzol, and used in making lubricants, soaps, leather-dressing, etc.

The quality from the jaw of the porpoise is used as a lubricant for watches.

According to C. M. Tucker, the oil from the head of *Tursiops truncatus* showed $d^{15·5}$ 0·9241; $n^{20·5}_{D}$ 1·4519; sap. v. 293; i.v. (Hanus) 28·3; Reichert-Meissl v. 139; acid v. 2·88; and the approximate analysis as: dodecyl alcohol 18·7, glycerol 18·5, *iso*valeric acid 62·6, palmitic acid 6·1, oleic acid 3·5 per cent. (*B.C.A.*, 1930, B, 567).

Salmon Oil—A by-product of the canning trade, being a yellowish liquid of sp. gr. 0·9258, sap. v. 182 to 188, i.v. 161 to 190; soluble in alcohol, ether, etc., and used in soap-making and leather-dressing.

Sardine Oil is of a yellow colour, of sp. gr. about 0·93, sap. v. about 189, i.v. 158 to 190, and ref. ind. 1·48. It is soluble in alcohol, benzine, etc., and is used in soap-making and as a lubricant. A new acid constituent ($C_{16}H_{26}O_2$) has been recently described. (See Toyama and Tsuchiya, *B.C.A.*, 1929, A, 793; and Ikuta and Ueno on "Composition of the Saturated Fatty Acids of Japanese Sardine Oil" (*B.C.A.*, 1930, B, 1036).)

Seal Oil, derived from *Squalus maximus*, is white or straw-coloured, of sp. gr. 0·924 to 0·926, sap. v. of 189 to 196, i.v. 127 to 193, and ref. ind. 1·474. It closely resembles whale oil (*Balæna* genus); is soluble in benzene, chloroform, ether, and carbon disulphide; and is used in soap-making.

Sea-Wolf Liver Oil (from *Anarrhichas lupus* L.) is of golden-brown colour, curious odour, and contains about 92·2 to 92·4 per cent. fatty acids; sap. v. 182 to 185, and i.v. (Wijs) 118 to 131; used in Russia for mixing with codfish liver oil in the tanning industry.

Shark Oil (*Squalus acanthias*)—This liver oil closely resembles cod-liver oil, having a sp. gr. at 15° C. of 0·9248, sap. v. 188, i.v. 154 to 172, and ref. ind. at 25° C. of 1·4761. It can be hydrogenated to a

FISH OILS (*Continued*)—

solid state; is yellow to reddish-brown in colour, and in addition to its pharmaceutical applications can be used in soap-making, in paint manufacture, and for currying leather. It is also used as an adulterant of cod-liver oil. The unsaponifiable constituents of shark and ray liver oils are stated to consist chiefly of higher alcohols (butyl, chimyl, and selachyl alcohols). (See A. C. Chapman (*J.C.S.*, 1923, **123,** 769, and *Analyst*, 1927, **52,** 622); Y. Toyama (*J.C.S.*, 1925, p. 4); André and Canal (*B.C.A.*, 1930, B, 23); and Squalene.)

Sperm (**Whale**) **Oil**—The oils from the head and the blubber of the genera *Physeter* and *Hyperooden* (or sperm and bottle-nosed whales) differ in composition and are characterized by almost complete absence of glycerides, esters of the higher aliphatic alcohols taking their place. According to Hilditch, they exhibit the following analytical features:

Head oil: sp. gr. 0·878 to 0·880; ref. ind. $\frac{a\,\mathrm{D}\,25^\circ\,\mathrm{C.}}{1{\cdot}459}$; sap. v. 140 to 144; i.v. 60 to 76. Body oil: sp. gr. 0·871 to 0·877; ref. ind. 1·462; sap. v. 122 to 130; i.v. 80 to 93.

See other contributions concerning the wax esters; the general structure of the oils and quantitative determinations of the fatty alcohols present, by Hilditch and Lovern (*J.S.C.I.*, 1929, **48,** 359 to 368 T).

Sperm oil is used, among other applications, as a bath for immersion of steel hardened for cutting purposes before cooling. (See Whale Oils.)

Tope (**Liver**) **Oil** (*Galeus galeus*) has values very nearly like those of cod-liver oil—viz., sp. gr. (15°/15° C.) 0·9249, i.v. (Wijs) 152·2, sap. v. 185·1, ref. ind. at 15° C. 1·4803. It is of pale colour, rather strong odour, is used for leather-dressing, and is equal to cod-liver oil as a source of the fat-soluble vitamins.

Tuna Oil (**Tunny-Fish Oil**) is pale yellow to red-brown in colour, and is expressed from the livers of *Thynnus vulgaris*; i.v. about 156; soluble in alcohol, ether, etc., and used in paint-making, etc.

Other varieties of fish oils are obtained from black-fish and halibut.

A characteristic fatty acid of the fish-oil group is named *clupanodonic acid* ($C_{22}H_{34}O_2$), which notably occurs in the mixed fatty acids obtained from Japanese sardine oil, herring and whale oils, etc. It is a pale yellow liquid of fishy odour, which does not solidify at −50°, and readily oxidizes on exposure to the air to a varnish-like mass.

Whale Oil (**Blubber Oil**) is obtained chiefly from the blubber of *Balæna mysticetus* and many other species. There are a number of grades, varying in colour from almost water-white to yellowish-brown; it solidifies at about 2° C.; sp. gr. varying from 0·908 to 0·925, sap. v. 188 to 196, and i.v. 114 to 126. It is soluble in alcohol and ether, has a strong fishy odour, and is used in soap-making, for lubricating, tempering steel, and as a leather dressing. By hydrogenation it is converted into a hard, white, inodorous fat, constituting a good substitute for tallow. A tetradecylenic (tetradecenoic) acid ($C_{14}H_{26}O_2$) has been

FISH OILS (*Continued*)—
isolated from sperm oil. The Norwegian production of whale oil in 1922 was 342,290 barrels. See Y. Toyama (*Analyst,* 1927, **52,** 726) and Whale Oils.

Fish-meal (for the preparation of which many types of plant exist) contains from 8 to 10 per cent. oil and from 45 to 50 per cent. albuminoids, and is therefore used as a valuable feeding stuff for cattle, pigs, and poultry, also as a good fertilizer. Some 14,000 tons were produced in British Columbia (Canada) in 1928. The nature of its water-soluble nitrogen compounds, etc., is the subject of articles by W. L. Davies (*J.S.C.I.*, 1925, **44,** 488 T, and 1926, **45,** 25 T).

See article on the Norwegian fish-oil industry (*C.T.J.*, June 6, 1924); A. C. Hopper on "Fish By-Products" (*Ibid.*, 1925, **77,** 383); Hilditch and Houlbrooke on "Elasmobranch Oil" (*Analyst,* 1928, **53,** 246); H. M. Langton on "Fish and Marine Animal Oils" (*Chem. and Ind.*, 1928, **47,** 1334); table under heading of Oils, p. 634; Gaha, Hilditch, and Lovern on "The Composition of the Mixed Fatty Acids contained in the Glycerides of Cod-Liver and Some Other Fish-Liver Oils" (*Biochem. J.*, 1930, **24,** 266); Special Report No. 37 on "The Handling and Storage of White Fish at Sea" (H.M. Stationery Office, 1929); fish "pearl essence" under the heading of Pearls; and reference to a floating fish-products factory in the *C.T.J.,* **85,** 196.

FISH PRODUCTS—See Fish Oils and Oils.

FIXED OILS—See Oils.

FLAME—A heated rod in ether vapour produces a glow or kind of flame, and flame may be described as a perceptible feature of the combustion of gas in chemical interaction at a temperature sufficient to evolve considerable light as well as heat. Combustion of gases may occur without flame at temperatures below those necessary for ignition.

Some flame temperatures have been determined as follows: water gas, Bunsen burner and other gas flames ranging from 1,860° to 1,870° C.; hydrogen gas, 1,900° C.; oxyhydrogen, 2,800° C.; oxyacetylene, 3,300° C. David and Davies have shown that luminosity can be manifest in exploded gaseous mixtures long after chemical combination is completed: this is probably a matter of temperature, at which the more permanent gases remain luminous (*Phil. Mag.*, 1930 [vii.], **9,** 390).

Other References: See Chapman and Wheeler on "The Propagation of Flame in Mixtures of Methane and Air" (*J.C.S.*, 1927, p. 38); article on "Flame and the Combustion of Gaseous Mixtures" (*Ind. Chem.*, 1925, i., 17); Wall and Wheeler (*J.C.S.*, 1927, p. 291); Ellis and Wheeler on "The Movement of Flame in Closed Vessels" (*J.C.S.*, 1927, p. 153, and *Ibid.*, p. 310); N. Swindin on "Submerged Flame Combustion" (*Ind. Chem.*, 1928, iv., 467, and *Ibid.*, 1929, v., 529); C. F. Hammond on "History and Development of Submerged Combustion" (*J. Inst. Fuel,* 1930, **3,** 303); W. E. Garner on "Some Pro-

FLAME (*Continued*)—

perties of Flame and Combustion" (*Chem. and Ind.*, 1929, **48,** 186); Maxwell and Wheeler on "The Inflammation of Mixtures of the Olefines and Air" (*J.C.S.*, 1929, p. 245); R. P. Fraser on "Flame Movement in Gaseous Explosions" (*J.S.C.I.*, 1930, **49,** 99 T); W. A. Bone on "Flame Speeds" (*Chem. and Ind.*, 1931, **50,** 603, and *Ibid.*, 1932, **51,** 116); W. M. Thornton on "Propagation of Flame and Gaseous Explosions" (*B.C.A.*, 1930, A, 708); Guénault and Wheeler on "Propagation of Flame in Electric Fields" (*J.C.S.*, 1931, p. 195); Kirby and Wheeler on "Explosions in Closed Cylinders" (*J.C.S.*, 1931, p. 847); O. C. de C. Ellis on "Explosions in Closed Containers" (*J.S.C.I.*, 1931, **50,** 403 T); E. W. Steacie on "Thermal and Chain Explosions" (*Chem. and Ind.*, 1932, **51,** 208); "Gaseous Combustion in Industry," by R. V. Wheeler (*Chem. and Ind.*, 1931, **50,** 559); Bone, Newitt, and Townend on *Gaseous Combustion at High Pressures* (Longmans and Co., 1929); also Burners, Combustion, Detonators, Flash-point, Heat, Ignition, Light, and Methane (p. 453).

FLAME COLORATION—Many chemical compounds communicate distinct coloration to an otherwise colourless or nearly colourless flame, such as that of the blow-pipe or Bunsen burner. (See Boron and Light (Spectroscope).)

Potassium salts give a lilac colour to the flame.
Sodium ,, ,, yellow ,, ,,
Calcium ,, ,, brick-red ,, ,,
Barium ,, ,, green ,, ,,
Strontium ,, ,, red ,, ,,
Magnesium ,, ,, white ,, ,,
Copper ,, ,, green ,, ,,
Lithium ,, ,, brilliant crimson colour to the flame.
Lead, arsenic, and antimony compounds give a bluish-white colour to the flame.

FLASH-POINT is the temperature at which an oil or other combustible liquid gives off vapour, which will then fire or explode if mixed with air and exposed momentarily to a naked light. The appliance most commonly used in this country for determining flash-points is one known as Abel's; others are the Abel-Pensky, Pensky-Marten's, Gray's, etc.

"That mixture containing the minimum amount of fuel gas or vapour capable of producing an explosion on ignition is known as the lower ignition mixture, and that containing the maximum amount of fuel which will still explode on ignition as the upper explosive mixture. In dealing with liquids, the lowest temperature at which the liquid in contact with air will give the explosive mixture with the minimum amount of fuel is known as the lower flash-point, and the lowest temperature at which the liquid will give an explosive mixture with the maximum amount of fuel is known as the upper flash-point."

The flash-point is an empirical constant depending to some extent upon the particular apparatus used for determining it. Ormandy and Craven, in a communication to the Institution of Petroleum Technologists, have given the following figures as made by the Pensky-Marten tester:

FLASH-POINT (*Continued*)—

	Flash-Point. (Degrees C.)	Boiling-Point. (Degrees C.)		Flash-Point. (Degrees C.)	Boiling-Point. (Degrees C.)
Monochlorbenzene ...	29	132	Benzoic acid ...	121	249
Dimethylanilin ...	61	192	*p*-Nitrochlorbenzene	127	242
Benzaldehyde ...	62·5	179	*m*-Dinitrobenzene ...	150	297
p-Dichlorbenzene ...	67	172	α-Naphthylamine ...	157	300
Anilin	71	184	β-Naphthol	161	286
o-Cresol	81	188	Dinitrochlorbenzene	187	315
Nitrobenzene ...	89	208			

They found there is an approximately linear relation between the flash and boiling-points measured on the absolute scale, the ratio being very close to 0·734. They have also determined with their new instrument the flash-points of other liquids as listed below.

Name of Article.	Initial Boiling-Point.	Low Flash.	High Flash.
	Degrees C.		
Kerosene (American)	165	48½	76½
Kerosene (Borneo)	148	42	68
Kerosene (Mexican)	140	31	56
Petrol (Pratt's No. 1)	57	−28	—
Petrol (Red Line)	58	−27	−4
Petrol (Shell)	63	−25	½
Hexane (64 to 71)	64	−26	1
Heptane (pure)	-98	− 1	17
Benzene	80	−12 (solid)	10
Toluene	109	10	30
Xylol	138	29	50
Naphthalene	218	86	—
Cyclo-hexane	79	−17 (solid)	—
Tetraline (crude)	132	39	—
Methyl alcohol	64	− 1	32
Ethyl alcohol	78	11	32
Propyl alcohol	95	24	45½
Turpentine	150	38	55
Acetone	56	−18	2
Ether (methylated)	35	−41	—
Ether (pure)	34	−41	−27

The difference between the results obtained, using the various kinds of apparatus, lies, to some extent, in the variations in the ratio of the vapour space above the liquid to the volume of the latter, the vapour pressure having an important influence on the flash-points. At the flash-point in air, all hydrocarbons have approximately identical vapour tensions. The flash-point is raised by the increase of pressure, while it is lowered when oxygen is substituted for air. (See Ignition.)

FLASKS are glass vessels of varying shapes for holding liquids, consisting of a body part with (generally) flattened bottom, having a neck which can be easily grasped by the hand or held by a clamp, and closed with a stopper when required. The glass of which they are made is of a quality to permit the contents to be heated (as when placed on a sheet of wire gauze over a lamp or on a heated sand-bath) to the temperature of boiling water. (See Aspirator and Gas Generators.)

Dewar Flask—See Vacuum.

Erlenmeyer Flasks are of conical type, having flat bottoms of diameter equal to from half to three-quarters of the height, and with side surface tapering smoothly from that base to the bottom of the neck, which is short, narrow, and straight-sided. They have the advantage of being more easily washed out than round flasks, but are somewhat more liable to crack on heating.

FLAVIN—A yellow dyestuff imperfectly soluble in water (possibly identical with quercitrin) prepared from quercitron bark and imported from the U.S.A. (See Quercitrin.)

FLAVONE ($C_{15}H_{10}O_2$)—The parent substance of a number of yellow dyes found in the vegetable kingdom, many of which occur as glucosides.

The flavone family is usually divided into "flavone" and "flavonal" compounds, and there appears to be a genetic relationship between the flavone and anthocyanin series of bodies, inasmuch as cyanidin can be produced from quercitrin by a reduction process. (See Allan and Robinson (*J.C.S.*, 1924, **125,** 2192); Baker and Robinson (*J.C.S.*, 1929, p. 152); also Galanga, Morin, Plant Colouring Matters, and Quercitrin.)

FLAVOURING MATERIALS—See book by A. Clarke (Oxford Univ. Press).

FLAX (*Linum usitatissimum*) is a plant (genus Linaceæ) extensively grown in Ireland, Belgium, Germany, France, Russia, and other countries for the sake of the fibre (which is the raw material of linen), the linseed oil which is extracted from it by pressure, and the residual cake which is used for cattle food. It contains from 32·77 to 38·42 per cent. of fat, including about 1·65 per cent. wax, and from 3·33 to 5·29 per cent. nitrogen. Flax wax is for the most part found present in the fibre and cortical tissues, the air-dried cortex sometimes containing as much as 10 per cent. Various varieties of the wax have a sap. v. of 77·5 to 83·7, i.v. 21·6 to 28·8, acid v. 17·5 to 23·8, m.p. 67·3 to 69·8, and sp. gr. 0·963 to 0·985, the water-retted kinds being richer in wax than the dew-retted. It is stated to contain ceryl alcohol and cerotic acid, takes a high polish, and can be used as a substitute for beeswax for some applications. Its employment as a possible industrial material is the subject of an article by W. H. Gibson (*C.T.J.*, 1931, **88,** 224). New Zealand flax is an important fibre derived from a different plant—viz., *Phormium tenax,* of the order Liliaceæ.

The pectin content of various flaxes appears to range from 4·46 to 7·02 per cent. (W. Kind, *B.C.A.*, 1926, B, 911), while that of flax fibre

FLAX (*Continued*)—

bundle when separated from cortical tissues is under 2 per cent. (See Nanji and others (*J.S.C.I.*, 1925, **44,** 253 T); Trevethick and others (*B.C.A.*, 1929, B, 638); and S. T. Henderson (*J.C.S.*, 1928, p. 2117).)

The retting of flax is a process for preparing it by soaking and maceration, involving in large measure the action of associated bacteria, and is conducted in order to remove the boon or woody part and associated gummy and resinous substances. (See Oméliansky and Konowov (*B.C.A.*, 1927, B, 57).)

The waste liquor obtained as the result of retting flax contains large proportions of organic matters, and requires to be purified either by chemical precipitation with lime and aluminium sulphate, biological treatment, or irrigation overland, before discharge into streams.

Fibres of flax and ramie can be distinguished from those of hemp, after isolation in warm water, by viewing them while drying in a warm room, as they always twist in a clockwise fashion, while hemp and jute rotate in an opposite direction. The constituents of the cell-wall of flax fibre is the subject of an article by A. E. Cashmore (*J.C.S.*, 1927, *Trans.*, p. 718). (See also notes on the "Cottonisation of Flax," by Axipetrov and Rioumin (*B.C.A.*, 1931, B, 477), and by B. M. Lotarev (*Ibid.*); Lignin, Linseed Oil, Pectins, and Waxes (Flax).)

FLEASEED—See Pysllium Seed.

"**FLEXSTEL**"—Patented expansible and flexible joints in steel and other metals capable of withstanding fluctuating and intermittent pressures.

FLINT—A variety of quartz. (See Silica.)

FLORESCENCE—A term used in respect of the crystallization of soluble salts on the surfaces of building materials.

"**FLORIDIN**"—A variety of fuller's earth found in Florida (U.S.A.), used in granulated form (16 to 30 mesh per inch), after ignition at 900° F., as a decolourizing agent in wax-refining, etc., and admitting of regeneration by furnacing.

FLORIDOSE—An aldehexose occurring in the red sea-weed *florideæ,* etc.

FLOTATION OILS AND PROCESS—See Ores (Treatment).

FLOUR—See Wheat.

FLUE GAS PURIFICATION—See S. L. Pierce (*C.T.J.*, 1930, **87,** 378 and 537); Effluents, Gas Washing, Sulphur.

FLUELLITE ($AlFe_3.H_2O$)—A native fluoride of aluminium (crystal system, No. 4, and sp. gr. 2·17).

FLUID METERS—For the continuous measurement of water and other fluids, are appliances screwed on to the pipe circuits, involving the revolution of a vane or paddle-wheel at a speed corresponding to the flow through the meter, the "Glenfield" inferential rotary meter being one such contrivance. (See *Ind. Chem.*, 1925, i., 349; 1931, vii., 520; and H. M. Brown, *Ibid.*, 1927, iii., 128.)

FLUOR (**Fluorspar, Fluorite**)—See Fluorine.

FLUORAPATITE—A mineral of composition $3P_2O_8Ca_3,CaF_2$.

"**FLUOREMETIC**"—A double soluble fluoride of antimony and sodium, being a clear white crystalline salt largely used in the textile trade.

FLUORENE or diphenylene-methane ($C_6H_4.C_6H_4.CH_2$) is contained in coal tar and can be obtained by passing diphenyl-methane through red-hot tubes. It is a white crystalline substance exhibiting a violet fluorescence, of m.p. 113° C. and b.p. 295° C. (See C. Courtot, *B.C.A.*, 1930, A, 1424, and M. A. Phillips (on its bromination), *J.C.S.*, 1932, p. 724.)

FLUORESCEÏN (**Resorcinol-phthalein**) ($C_{20}H_{12}O_5,H_2O$) is a dark red, crystalline powder, soluble in alcohol to a yellow-red colour, and in alkalies to a red colour, showing a fine green fluorescence. It is easily reduced to the phthaline "fluorescin," and by bromination gives the potassium salt known as the dye eosin. These substances are extensively used in the dyeing industries. (See Eosin.)

FLUORESCENCE—The property of producing opalescent colour or bloom different from that of the liquid or substance which exhibits it, said to be dependent upon the absorption of radiant energy of certain wave-length and emitting it as waves of greater length. It has also been suggested by O. Oldenberg that fluorescence is due to molecules which have been activated by absorbed radiation returning to their normal state (*B.C.A.*, 1926, A, 992). According to S. Dutt a number of organic compounds lose their fluorescence on exhaustive purification and recover same on keeping in air for some days or more time (*B.C.A.*, 1930, A, 13). Later views and the more precise relationship of fluorescence with phosphorescence have been expounded by Baly (*Chem. and Ind.*, 1928, **47**, 917). Green crystals of fluorspar give blue reflection, the alcoholic solution of anisole and quinine sulphate solution are strongly fluorescent, and many solutions exhibit fluorescence under the influence of ultra-violet light. (See J. Moir (*J.C.S.*, 1925, ii., 261) and F. Perrin (*B.C.A.*, 1930, A, 133).)

FLUORINE (F) **and its Compounds**—Atomic weight, 19; m.p., −223° C. Fluorine is found in nature combined with calcium in the mineral *fluorspar* or *fluorite* (CaF_2), also known as *Derbyshire spar*, of crystal system, No. 1, and sp. gr. 3·15 to 3·20. It is quarried in large quantities at Weardale and Alston, while workable deposits occur near Ottoshoop, Zeerust, South Africa. Fluorine is also a constituent of *cryolite* (Na_3AlF_6)—a double fluoride of sodium and aluminium found in Colorado and Greenland—and some other minerals, and present in small quantities in bones and the enamel of teeth.

Fluorspar occurs in blue and green forms, and sometimes consists of 99·5 per cent. calcium fluoride (CaF_2). The fluorspar production in this country amounted in 1918 to 53,498 tons, of which 30,000 tons were used for fluxing purposes and in the glass and enamel industries.

FLUORINE (*Continued*)—

Fluorine can be obtained in quantity by the electrolysis of fused potassium-hydrogen fluoride (KF.HF), one electrode being of graphite, the other consisting of the copper container, the evolved gas being purified by passage through copper tubes filled with sodium fluoride in order to remove the hydrogen fluoride. It can also be prepared quite simply by the electrolysis of fused acid fluorides, such as KF,3HF, using carbon-free iron or nickel anodes, the nickel or copper-containing vessel acting as cathode. By another process it can be made by the electrolysis of anhydrous hydrofluoric acid at −23° C. It is, at ordinary temperatures, a pale yellowish gas of very active chemical, corrosive, and poisonous qualities, which attacks glass with avidity, but is insoluble in water. When cooled to a temperature of −187° C., it condenses to the liquid state in the form of a mobile yellow fluid with a characteristic odour something like that of chlorine, and at a still lower temperature it assumes an almost solid white form.

Fluorine attacks organic substances with violence; acts strongly upon all metals (even gold and platinum to some extent), many of them passing into a state of inflammation when thrown in a finely divided state into the gas.

A combination with hydrogen known as hydrofluoric acid gas (HF) is made by warming a mixture of strong sulphuric acid and powdered calcium fluoride (fluorspar) in a leaden or platinum vessel:

$$CaF_2 + H_2SO_4 = CaSO_4 + 2HF,$$

the evolved gas being condensed in water. It can also be made by distillation of anhydrous acid potassium fluoride. It freezes at −83° C., and is surmised to consist of an equilibrium mixture of HF and $(HF)_6$.

It is largely employed in the purification of graphite from silica, for polishing glass, cleansing iron castings, and removing vitreous enamels from sheet steel. It is used also for etching purposes, as, for example, making the graduations on glass measuring apparatus: the object to be marked in this way is coated with melted wax, and after tracing the design or marks on the coated glass, it is exposed (after cooling) to the action of the acid either in the form of gas or liquid, with the result that the glass is eaten into where exposed by the markings, the fluorine having no action on the wax. A mixture that can be used for etching glass is made by well mixing equal weights of ammonium fluoride and dry precipitated barium sulphate together with hydrochloric acid and adding fuming hydrofluoric acid to a suitable consistency. (See W. S. Kahlson, *B.C.A.*, 1932, B, 104.)

Hydrofluoric acid vapour is irritating and injurious to the respiratory organs, while the liquid produces ulcerated sores on the skin, and is altogether a very dangerous chemical compound. The anhydrous acid is a limpid colourless liquid which boils at 19·5° C. For commercial purposes, an aqueous solution of this acid of 60 per cent. strength (density 1·182) is produced, and this can be transported in steel drums in accordance with certain railway companies' specification.

There are fluorides corresponding to the chlorides and also a number

FLUORINE (*Continued*)—
of double fluorides. The fluorides of potassium, sodium, and iron are but sparingly soluble in water, while the fluorides of silver and tin are easily soluble. Most of the fluorine compounds are easily fusible, and when ignited in a current of steam many of them are converted into oxides, hydrofluoric acid being evolved.

Potassium and sodium fluorides (KF and NaF) are used in compounding casein cement or the so-called "cold glues" and as preservatives for wood, etc.

Manganese and cadmium fluorides have been studied by P. Nuka (*B.C.A.*, 1929, A, 779), and oxygen fluoride gas of the composition F_2O has been described (Lebeau and Damiens, *B.C.A.*, 1929, A, 779).

The potassium hydrogen or acid fluoride (KF.HF), sometimes called bifluoride, has already been referred to. It is obtained in an anhydrous state by evaporation of a solution of potassium fluoride in aqueous hydrofluoric acid, followed by heating to 110° C., and upon further heating to dull redness it is decomposed into the normal salt and hydrofluoric acid.

Sodium acid fluoride (sodium-hydrogen fluoride) (NaF.HF) is a dry white substance, useful, in the form of a warm solution, for removing iron-mould.

Ammonium difluoride (ammonium-hydrogen fluoride) ($NH_4F.HF$) is a white crystalline body, soluble in water, used in alcohol manufacture for inhibiting the growth of acetic and lactic organisms, also as a brewery antiseptic; and in common with the corresponding potassium and sodium compounds for frosting glass.

Many of the double salts, such as antimony-sodium fluoride (SbF_3NaF), are used as mordants instead of tartar emetic (see "Fluoremetic"). Sodium silico-fluoride (Na_2SiF_6) finds use as an insecticide (also in the ceramic industries as a substitute for cryolite and as a preservative of rubber latex), while lead silico-fluoride ($PbSiF_6$) (a very soluble salt) has been used in refining lead ores.

Calcium fluoride, which is practically insoluble, is used in the enamelled iron industry, and its employment in the foundry is the subject of an article in the *C.T.J.*, 1910, **46**, 481. Chromium fluoride ($Cr_2F_6.8H_2O$), a green crystalline salt, is used to some extent in calico printing, and zinc fluoride is used as a wood preservative. A table giving the solubilities of a number of fluorides is reproduced in the *C.T.J.*, 1928, **83**, 479. (See also Silicon Compounds.)

FLUOSILICATES—See Silicon Compounds.

"FLÜSSIGGAS"—That fraction of cracked oil gas available for transport by compression into steel cylinders at ordinary temperatures, which is reconverted into gas upon releasing the pressure; used for lighting of buoys, railway carriages, etc. (C. Gerdes, *B.C.A.*, 1930, B, 801.)

FLUXES—Substances or mixtures used to assist fusion by heat. One such flux is a mixture of nitre and tartar, and it is either placed in the

FLUXES (*Continued*)—
crucible in which the mineral is to be fused or gradually introduced. The oxygen of the nitre causes the combustion of the carbon of the tartar and assists to raise the temperature of the mass.

Potassium cyanide and other chemicals are used as fluxes according to the nature of the mineral or other substances to be fused.

"Black flux" is a mixture of potassium or sodium carbonate, sodium nitrate, and carbon, used in assaying; and "white flux" is a mixture of sodium carbonate with sodium nitrate and sodium nitrite, used in metallurgy and welding.

A flux and solder for use especially with cast-iron is made from 45 per cent. zinc chloride, 40 per cent. sal-ammoniac (ammonium chloride), and 15 per cent. metallic zinc.

A patented flux for hard soldering is stated to consist of a mixture of borax and sodium phosphate melted at from 800° to 900° C. to a glassy mass.

A good flux for aluminium work and general purposes consists of potassium chloride 15 parts, sodium chloride 30 parts, lithium chloride 45 parts, potassium fluoride 7 parts, and potassium bisulphate 3 parts.

For brazing purposes, borax and boracic acid are variously employed, a mixture of the two substances being used in soldering rustless steels. Among other preparations used dry or in solution are zinc chloride for brass, copper, gun-metal and tin-plate; ammonium chloride for copper and iron; and hydrochloric acid for zinc and galvanised materials.

Resin is used for some soft alloys, turpentine for pewter and Britannia metal, palm oil and tallow for light or heavy lead work. (See *C.T.J.*, August 17, 1923; also Alloys, Refractories, Solders and Tartar.)

FOCUS—The point at which the rays of light converge after passing through a convex lens.

FOG—See Air and Mists.

FOIL, or a thin sheet of metal, finds frequent use by chemists. Platinum foil is particularly useful, inasmuch as it is not acted upon by most chemicals, withstands exposure to high temperatures, and is consequently employed to test the behaviour of solid substances when exposed in crystal or powder form to heat, varying from mere warming up to redness, for which purpose it is held by tongs or forceps. If, for instance, a small quantity of crystallized borax ($Na_2B_4O_7 10H_2O$) be placed on a piece of platinum foil and heated over a Bunsen flame, it will be seen to swell up, lose its water of crystallization, and finally fuse to a clear glass-like appearance. Lead, copper, tin, zinc, aluminium, and magnesium are also prepared in the form of foil.

FOODS are the other substances which, in addition to water and air, serve to repair the various tissues of the body and to renew its energy. They are generally classified under the headings of proteins (albuminoid matters), carbohydrates (starch, sugar, etc.), and fats, although vegetable acids and mineral salts are essential to a perfect dietary, as

FOODS (*Continued*)—

also a small quantity of the substances called hormones (which are secreted in the body by certain glands) and vitamins. Tea, coffee, and alcohol are often regarded as mere stimulants or accessories, but while tea and coffee may be so viewed, alcohol is a real food when taken in moderation, all of it being consumed by oxidation in the body, thus serving to replace so much other food. The general view is that starches, sugars, and fats give energy and heat, and that the growth-producing foods consist of dairy produce and fleshy materials, vegetables, fruits, and puddings. (See A. M. Wright and J. C. Forsyth on "Edible Viscera" (*J.S.C.I.*, 1927, **46,** 36 T); Hormones and Vitamins.)

"Glutathione" is a tripeptide of glutamic acid, cysteine, and glycine present in most active living tissues, and stated to be of great importance, owing to its properties of suffering reversible oxidations and reductions. It has been separated from yeast, from the mammalian muscle and liver and the livers of various fishes. From its composition, "glutathione" supports the views that many typical biological oxidations are in reality processes of dehydrogenation. (See *Biochem. J.*, 1921, **15,** 286, and 1925, **19,** 787; Hunter, Eagles, and Hopkins (*B.C.A.*, 1927, A, 478); F. G. Hopkins (*Chem. and Ind.*, 1929, **48,** 991); and Kendall, McKenzie, and Mason (*J. Biol. Chem.*, 1929, **84,** 657), who give the formula $C_{10}H_{17}O_6N_3S$ and m.p. 190° to 192° C. for its crystalline form as prepared from bakers' yeast.)

Food values are often calculated in terms of calories (heat units), a kilo-calorie being the quantity of heat sufficient to raise a kilogramme (1,000 c.c.) of water 1° C., and it is reckoned that proteins and carbohydrates each produce 4·1 calories for every gramme consumed as against 9·3 calories for each gramme of fat consumed.

A committee of the Royal Society reported during the Great War that each man engaged in active work requires per day 100 grms. or 3½ ozs. protein (albuminoids), 100 grms. or 3½ ozs. fat, and 500 grms. or 17½ ozs. carbohydrates, totalling approximately 3,400 calories per man per day. As against this, a man who takes little exercise and leads a sedentary life, 2,000 to 2,500 calories may suffice. In this connection it should be remembered that fats and carbohydrates are to some extent interchangeable, the soft fats being more easily digested than the harder ones of higher melting-points, and both are similarly interchangeable with alcohol to some degree. Food values, however, should not be calculated exclusively in terms of calories, but also in respect of their energy contents, in which direction healthy, sunlit-grown vegetable matters are of great importance.

The relative food values of white flour and wholemeal flour are discussed by S. Dixon in his paper referred to at foot of this article.

Taking the five pre-war years, the following table gives the quantities in metric tons (2,205 lbs.) of the total foods imported and home produced. Some analyses of various advertised infant foods by the Queensland Government analyst are reproduced in the *Analyst,* 1925, **50,** 21; see also J. S. Remington (*Ind. Chem.*, 1927, iii., 155).

FOODS (*Continued*)—

	Amounts.	Protein.	Fat.	Carbohydrate.	Energy Value. Millions of Calories.
	Metric Tons.	Metric Tons.	Metric Tons.	Metric Tons.	
Cereals	4,865,000	549,000	63,000	3,628,000	17,712,000
Meat	2,685,000	356,000	799,000	—	8,890,000
Poultry and eggs, game and rabbits	331,000	42,000	31,000	—	461,000
Fish	848,400	91,000	17,000	—	531,000
Dairy produce (including lard and margarine)	5,231,800	199,000	686,000	258,000	8,253,000
Fruit	1,271,000	9,000	14,000	222,000	1,077,000
Vegetables	5,482,000	120,000	10,000	1,031,000	4,812,000
Sugar (including cocoa and chocolate)	1,657,000	5,000	18,000	1,572,000	6,633,000
Cottage and farm produce not included above	—	67,000	13,000	551,000	2,655,000
Total	—	1,438,000	1,651,000	7,262,000	51,024,000
		Grms.	Grms.	Grms.	Calories.
Per head per day	—	87	100	440	3,091
Per "man" per day	—	113	130	571	4,900

Food Canning—See "The History and Processes of Food Canning," by James Grant (*Ind. Chem.*, 1925, i., 226); "Lacquering of Food Containers," by A. Ll. Matthison (*Chem. and Ind.*, 1930, **49**, 474); "Description of a New Canning Factory" (*Ind. Chem.*, 1931, vii., 363); A. Samson on "Lacquer and the Canning Industry" (*Chem. and Ind.*, 1932, **51**, 95); Special Report, No. 40 (Dept. of Scientific and Industrial Research), Food Investigation (H.M. Stationery Office), concerning corrosion of tinplate containers; and the British Canning Industry number of *The Times*, November 17, 1931.

Food Preservatives—Although it is undesirable to use any materials for the preservation of foods whenever avoidable, there would be great wastage but for their appropriate use. There appears to be a consensus of opinion that formaldehyde and its derivatives, as also hydrofluoric acid, its salts and derivatives, must be ruled out as dangerous to health, whilst sulphur dioxide and sodium sulphite are viewed as objectionable to some extent upon the ground that they restore the normal colour of meat in a decomposed state without removing the toxic products of that change. On the other hand, it would appear that benzoic acid, certain benzoates, salicylic acid, and peroxide of hydrogen are all permissible in well-defined quantities for various applications, particularly the last-named substance, the antiseptic properties of which were first made known by the author of this encyclopædia, and are not sufficiently recognized or utilized. (See C. T. Kingzett, *Chem. News*, September 29, 1876.) With respect to boric acid there is a difference of opinion, some regarding it as harmless, and others as dangerous in some degree. The prohibition of preservatives for milk, cream, butter, margarine, and meat would lead to increased prices for these im-

FOODS (*Continued*)—

portant commodities, and unless they can be proved harmful, would be regrettable.

"Preservatives" under the new regulations do not include common salt, saltpetre, sugars, acetic acid or vinegar, alcohol, hops or hop extracts, spices and essential oils used for flavouring purposes, or any substance added to food by the process of curing known as "smoking."

Isothermic transport of foods reduces the risks of bacterial contamination and chemical and physical deterioration.

References: New regulations as to food preservatives, which restrict their use to sulphur dioxide (sulphites) and benzoates, and then only in certain cases and limited amounts (see *Chem. and Ind.*, 1925, **44**, 231, and 1925, **44**, 251); see Statutory Rules and Orders, 1925, 775 (H.M. Stationery Office; *Analyst*, 1925, **50**, 455, and 1927, **52**, 33 and 285); "A Study of 100 Outbreaks of Food Poisoning," by Savage and White (Medical Research Council), obtainable at Adastral House, Kingsway, W.C. 2; "The Bacteriological Examination of Foods and Water," by Dr. Savage (*Analyst*, 1927, **52**, 117); "Colours in Foodstuffs," by H. Drake-Law (*J.S.C.I.*, 1926, **45**, 428 T); "The Problem of Pure Foods," by A. R. Tankard (*Ind. Chem.*, 1925, i., 358); "Processing of Foods preserved in Tins and Glasses," by O. Jones (*Ind. Chem.*, 1925, i., 422); "Recent Advances in the Low-temperature Preservation of Foodstuffs," by T. Moran (*J.S.C.I.*, 1929, p. 245 T); "Some Recent Food Investigations," by S. Dixon (*Chem. and Ind.*, 1930, **49**, 645 and 663); "Chemical Changes in the Fat of Frozen and Chilled Meat," by Colin H. Lea (*J.S.C.I.*, 1931, **50**, 207 T, 215 T, and 343 T); "Growth of Micro-organisms on Chilled and Frozen Meat," by R. B. Haines (*J.S.C.I.*, 1931, **50**, 223 T); "Rapid Freezing," by T. Moran (*J.S.C.I.*, 1932, **51**, 16 T) and Moran and Hale (*Ibid.*, 20 T); Food Number, *Chem. and Ind.*, 1932, **51**, pp. 81 to 97; L. H. Lampitt on "Science and Food" (*Ibid.*, p. 238); "Food Fakes," by E. G. Jones (lecture, Inst. Chem.); Reports of the Food Investigation Board (H.M. Stationery Office); *Food Infections and Food Intoxications*, by S. R. Damon (Baillière, Tindall and Cox); *Nutrition and Food Chemistry*, by B. C. Bronson (Chapman and Hall); *Food Preservation*, by W. W. Chenoweth (Chapman and Hall); *Scientific Preservation of Food* (by T. M. Rector (Chapman and Hall); *The Bacteriology of Food*, by C. Dukes (H. K. Lewis and Co.); *Foods: their Composition and Analysis*, by A. and M. Wynter Blyth, 7th edit. (C. Griffin and Co.); *Analyses and Energy Values of Foods*, by R. H. A. Plimmer (H.M. Stationery Office); *Colloid Aspects of Food Chemistry and Technology*, by W. Clayton (J. and A. Churchill); *Index to the Literature of Food Investigation*, by Miss Glennie (H.M. Stationery Office); Canning, Feeding-Stuffs, Proteins, Refrigeration, Vitamins, and Wheat.

FOOT-POUND—See Force.

FORCE—Force may be regarded as the potential status of energy (exercised force). Sunshine is the source of practically all force on

FORCE (*Continued*)—

earth, and this exhibits a tendency to flow downhill to a lower level, constituting the so-called law of katergy. Matter and force are inseparable and interdependent; there is no force without matter, and no matter without force. Indeed, it may be said that the different kinds of matter owe their individual characteristics to the forces that meantime rule their existence as entities.

A metallic wire is affected by and conducts the electric current; a strip of metal conducts the heat to which it may be exposed from one end to the other. It is through the medium of the matter filling the spaces between, that the light from the sun and the moon is conveyed to the earth.

Force, like matter, is indestructible and unchangeable except as to its form or variety: just as matter can be made to change its form and properties, so force can be made to change its form and character. Heat can be changed into light; light can be transformed into heat; electricity can be changed into light and heat; and all may be converted into mechanical action or power.

Sugar is a carbohydrate, consisting of carbon in combination with the elements of water, and if strong sulphuric acid be allowed to fall upon a lump of sugar and gentle warmth applied, a great chemical change rapidly occurs. The acid seizes upon the water elements with tremendous avidity, and the carbonaceous part of the sugar is set free in the form of a black mass. Some of the water thus seized by the acid is evaporated owing to the great heat that is evolved in this chemical interaction. Now, where does the heat come from? Both the sugar and the acid are only warm to start with, yet directly they meet, great heat is developed. It must come from forces locked up in the sugar and the acid. Some of it causes evaporation of the water which the acid takes out of the sugar, and heat or its equivalent is lost to what was originally a mixture of sugar and acid. In other words, there is a dissipation of force in the form of heat that was in some way locked up in the two varieties of matter which, when placed in contact, underwent chemical change attended with the results here described. (See Chemical Interactions, pp. 173-176.)

So, again, in the burning of a wire of magnesium metal in the air, not only is great heat given off, but also much bright light, showing that magnesium and oxygen do not consist of mere inert matter as something distinct from force, but that they are, like all other substances, compounded of the two things. (See Matter.)

Mechanical force is capable of bringing about certain chemical changes: for example, a mixture of potassium chlorate and sulphur undergoes chemical change with explosive violence when placed upon a hard surface, as of iron or stone, and hit with a hammer, or when rubbed together with a pestle in a mortar. It may be, however, that in this case the energy or the friction causes the local emission of heat, as in the striking of matches, and that the heat thus developed is the *immediate* cause of the chemical changes that are induced.

Again, a mixture of hydrochloric acid and phosphine (phosphoretted

FORCE (*Continued*)—

hydrogen) gases, when exposed to pressure, undergoes chemical combination, and there is produced a solid crystalline substance known as phosphonium chloride (PH_4Cl). The same compound is produced also by passing the mixed gases through a tube immersed in a freezing mixture, and it is again dissociated into the originating substances when exposed to the air under normal pressure.

Force takes a part in every chemical change, but this part is, unfortunately, not revealed by the symbolic equations used by chemists to represent the more material sides of these changes. For example, the equation

$$SO_3 + H_2O = H_2SO_4$$

expresses the formation of sulphuric acid by a combination of sulphur trioxide and water, but it does not reveal the fact that the combination involves an expenditure of energy disengaged as heat sufficient to raise the temperature of 213 grammes (cubic centimetres) of water from 0° to its boiling-point of 100° C. (See Formulæ.)

A mass of 772 pounds falling through 1 foot of space produces by friction sufficient heat to raise the temperature of 1 pound of water 1° F. When water is changed into ice a certain amount of heat is evolved, and, on the other hand, when water is changed into steam a larger amount of heat is absorbed.

Again, when nitrogen trichloride is suddenly heated, it explodes with great violence and is resolved into its elements:

$$2NCl_3 = N_2 + 3Cl_2,$$

and in this change a tremendous amount of energy is used up in overcoming the atmospheric pressure, which acts as a restraining influence.

Pressure, like temperature, is an important factor in chemical interactions, the use of high pressure being employed to bring out latent processes, otherwise unattainable, as, for example, the production of synthol, isopropyl alcohol, and the "berginization" of coal. (See Pressure (High).)

So with every chemical change: the energy that is expended may reappear as light or in electrical form, or in what is commonly regarded as its lowest degraded form—viz., heat; but there is no absolute destruction or annihilation of force. All matter being, as it were, made up of substance and force, there is a redistribution, but no loss of either when undergoing chemical change.

In other words, the law of conservation of force is expressed by stating that the total energy of any material system is constant, although transformable into any of the forms of which it is susceptible.

Chemical energy cannot be measured by any direct method, but so far as it is transformed into heat it admits of measurement, and thermo-chemistry is based upon the measurements of heat units.

The view has been expressed that possibly, or indeed probably, all molecular forces are essentially electrical in origin, and that surface tension is dependent on electrical attraction. That the recent investigations concerning the atomic structure of chemical entities lead to the

FORCE (*Continued*)—

conclusion that all forms of matter are to be ascribed to movements of the ultimate particles of two primordial elements in the nature of positive and negative electricity is not definitely established. It is far more likely that while there may be oneness of ultimate matter, all its changes are to be attributed to the forces, whatever they may be, that control it, determine all its individualities, and are indissolubly bound up with it.

Work may be defined as the exercise of force (energy) to overcome resistance, as exhibited, for example, by locomotives, petrol motors, and dynamic machines, the force per unit area being expressed in dynes per square centimetre and pounds per square inch.

It is said that energy may travel at a rate different from that of the waves with which it is associated and by which it is directed.

Some factors are appended:

C.G.S.—The centimetre-gramme-second system of physical units.

Erg—The unit of work in the centimetre-gramme-second (C.G.S.) system of physical units, or the work done by the force of 1 dyne moving through 1 centimetre.

One joule $= 10^7$ ergs.

Foot-Pound—The unit of work required to lift a pound mass through a distance of 1 foot.

Dyne—The unit of force in the centimetre-gramme-second system, or that which, acting upon a mass of 1 gramme for 1 second, produces unit velocity (1 centimetre per second).

Joule—10^7 absolute units of work (ergs) or 1 volt-coulomb represented by the energy expended in 1 second by 1 ampère in 1 ohm.

One joule $= 0{\cdot}2382$ calories, and one calorie $= 4{\cdot}183$ joules.

Horse-Power—The unit of power, being equal to 33,000 foot-pounds of work per minute. (See Foot-Pound.) 1·34 horse-power = 1 kilowatt, and 1 horse-power = 1·014 metric horse-power.

Kilowatt—C.G.S. unit of power = 1,000 watts (*q.v.*); 1 kilowatt = 1,000 joules per second or 1·341 h.p.; 760 kilowatts = 1,000 horsepower; 1 kilowatt = 238·7 calories per second.

Kinetic Energy—That possessed by a body in virtue of its motion, as exhibited by gases in confined spaces.

Poundal—The unit of force which, acting on a pound mass for 1 second, gives to it a velocity of 1 foot per second.

One poundal = 13·825 dynes.

Watt—The unit of power in the C.G.S. system, or capable of delivering 1 joule in 1 second. (See also Electricity, Electrons, Elements, Energy, and Radio-activity.)

FORENSIC CHEMISTRY—See Biochemistry, Bacteria, and Chemotherapy.

FORMALDEHYDE (FORMALIN) or METHYL ALDEHYDE (CH_2O or H.CHO) is a gas soluble in water, which liquefies at –20° C. to a colourless solution of density 0·815, solidifies at –92° C., and has a very irritating action on the mucous membranes of the eyes, nose and throat. An aqueous solution of 40 per cent. strength is an article of commerce, largely used under the name of Formalin for disinfecting and preservative purposes. It is made by a contact action brought about by passing a current of methyl alcohol vapour admixed with air (prepared by the passage of an air-current through heated methyl alcohol) over a glowing platinum or copper spiral or netting, and absorption of the resulting gas in water, in which solution it has the hydrate formula $CH_2(OH)_2$. (See Anton Siegl, *C.T.J.*, 1927, **81**, 419.)

It is also obtained, together with methyl alcohol, by the oxidation of methane, using carbon dioxide, the mixed gases being heated by a suitable contrivance to 500° to 700° C., and the products of the interactions rapidly cooled. The following reactions would appear to occur in the process: $2CO_2 = 2CO + 2O$ and $CH_4 + 2O = H.CHO + H_2O$. Under favourable conditions, the yield of formaldehyde is stated to amount to about 56 per cent. calculated on the methane used, the yield of methyl alcohol being favoured by slow passage of the gases. The activity of various catalysts in promoting this oxidation has been studied by J. R. Campbell (*J.S.C.I.*, 1929, **48**, 93 T). He found palladium and platinum black superior to silver, copper, and vanadium oxides. In another process now receiving attention nitric oxide is employed for the oxidation of methane, the mixed gases being heated together in a chamber at from 250° to 560° C. in presence of broken pieces of fireclay, when the whole of the methane is converted into formaldehyde associated with other products.

Formaldehyde possesses the property of making gelatine and glue insoluble in water, and this is utilized in many technical applications, including tanning, the preservation of adhesives and anatomical specimens. It is also used in making "bakelite," "formite," "galilith," "margalite," "resinite," etc. (See Gums and Resins (Synthetic).)

Among other applications may be mentioned its uses in the treatment of certain dyestuffs on the fibre to make them fast to washing and milling, hardening leather, in waterproofing, as a reducing agent, and in the recovery of rare metals. Its employment as a food preservative has been prohibited in this country on account of its poisonous character. (See Foods.)

The polymeric solid white paraform is more useful for disinfecting rooms by fumigation, as it is easily vaporized, and equally effective per unit of active agent. (See Paraform and Fumigation.)

Formaldehyde undergoes condensation when heated under 2 atmospheres pressure in aqueous solution in presence of magnesium oxide, the primary change leading to the production of methyl alcohol and formic acid; somewhat later, sugars are formed. (See *J.C.S. Abs.*, February, 1925, p. 1116.) It is believed to play an important part in the process of plant assimilation, and glycine has been synthesized from it. (See *Chem. and Ind.*, 1931, **50**, 3.) (See note on the concentration

FORMALDEHYDE (*Continued*)—

of aqueous formaldehyde solutions by E. W. Blair and R. Taylor (*J.S.C.I.*, 1926, **45,** 65 T); Report by Ledbury and Blair on Production of Formaldehyde (H.M. Stationery Office, 1927); also Photo-catalysis and Vegetation.)

Formaldehyde Resins.—The object of the earlier workers was to produce substitutes for shellac, but the peculiar properties of these products, notably their resistance to heat, electricity, and chemical action, have led to their adoption for many other purposes.

The products resulting from formaldehyde condensations with aromatic amines, phenols, and aromatic hydrocarbons are of value in respect of their bearing on the production of various industrial products, such as organic colouring matters, synthetic drugs, and artificial resins.

Some of the reactions with acid condensing agents lead to the production of fusible soluble resins of the "Novolak" type, while alkaline catalytic reagents favour the formation of insoluble resinoids. (See G. T. Morgan (*J.S.C.I.*, 1930, **49,** 245 T), and Megson and Drummond (*Ibid.,* 251 T.)

Air-drying varnishes and lacquers can be obtained from some of them, but their restricted solubility has proved of considerable difficulty. Synthetic resin varnishes are now largely used as stoving varnishes, and for coating insulating fabrics and tapes used in the electrical industry. (See Gums and Resins (Synthetic).)

"FORMALIN"—See Formaldehyde.

FORMAMIDE—See Amides.

FORMIC ACID (CH_2O_2 or HCOOH) occurs naturally in ants, in the sting of nettles, bees, and wasps, in the processionary caterpillar, the fruit of the soap-tree (*Sapindus saponaria*), fir needles and tamarinds, and is also formed as a by-product in the atmospheric oxidation of turpentine. When pure, it is a colourless liquid of sp. gr. 1·2178, which solidifies at $-1°$ C., boils at 100·8° C., and fumes in the air. It is a powerful antiseptic, very corrosive, and mixes with water in all proportions. The chief commercial source of formic acid is sodium formate ($NaCHO_2$), made by the action of carbon monoxide upon sodium hydroxide, and this, by interaction with sulphuric acid, yields formic acid of 90 per cent. strength. From this, the anhydrous acid can be obtained by distillation with strong sulphuric acid under reduced pressure.

A French catalytic process of manufacture is described by A. Dubose (*C.T.J.*, 1924, **75,** 303). For commercial purposes it is prepared of 85 per cent. strength, and finds industrial applications in the electroplating, textile, and tanning trades.

Carter and Bredig have recently discovered a method of preparing formic acid by the direct union of hydrogen and carbon dioxide, using pressure and palladium as a catalyst.

It slowly decomposes on storage, and much more readily upon heating. It is also decomposed by strong sulphuric acid into carbon

FORMIC ACID (*Continued*)—

monoxide and water, while in aqueous solution it is oxidized by the halogens into carbon dioxide and halogen acid, and is subject to photochemical decomposition. Formic acid is broken down by *B. coli* in two ways—anaerobically to $H_2 + CO_2$ and aerobically to $H_2O + CO_2$ (see L. H. Stickland, *Chem. and Ind.*, 1929, **48,** 992). It finds use in dyeing cotton and woollen textiles.

The formates are converted by heat into oxalates and hydrogen. (See Alacet.)

"FORMITE"—A proprietary phenol-formaldehyde product, used as an electrical insulating material and plastic cement. It is unaffected by oils and many solvents, while certain solutions of it are made up as varnishes for special application. (See "Bakelite.")

"FORMITE-BAKELITE CEMENT A.R." is a product for making self-hardening joints on engines, boilers, etc., stated to be resistant to steam, hot water, various organic liquids and vapours, weak acids, alkalies, oils, etc.

FORMOLITE RESINS—See Gums and Resins (Synthetic).

FORMOSE ($C_6H_{12}H_6$)—A mixture of glucoses (obtained by the action of alkaline condensing agents such as lime-water on formaldehyde), with which it is polymeric.

"FORMOSUL"—See Hydrosulphites.

FORMULÆ—The arrangement of symbols representing the chemical composition of substances. The symbols which are used are explained in the several sections dealing with Chemical Compounds, Chemical Interactions, and Elements, and the formulæ employed are of various types. The ordinary formulæ indicate the composition without respect to any particular molecular arrangement or structure; thus NaCl expresses the combination of 1 atom of sodium with 1 atom of chlorine in 1 molecule of salt. Again, the formula $(NH_4)_2SO_4$ expresses the combination of 2 of the groups NH_4 with 1 of SO_4 in 1 molecule of ammonium sulphate, and so forth.

The **Empirical** formula of a substance is ascertained from the results of its analysis, the percentages of elements found present being divided by their atomic weights. For example, hydrocyanic acid upon analysis is shown to contain as follows:

Hydrogen	3·704	per cent.
Carbon	44·444	,,
Nitrogen	51·852	,,

and if these percentages are divided by the atomic weights of the three elements—viz., $H = 1$, $C = 12$, and $N = 14$—it will be found that the quotients are practically identical, so that the component elements are combined in the proportions of one each—viz., HCN, which is the simplest formula of the substance.

Or again, taking salt (sodium chloride), it yields upon analysis

FORMULÆ (*Continued*)—

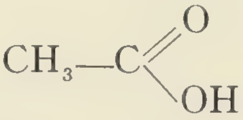
39·316 per cent. sodium and 60·684 per cent. chlorine, and the division of these numbers by the atomic weights 23 and 35·5 shows the two components to be contained in the elemental proportions, so that the empirical formula is NaCl.

Constitutional or **Rational** formulæ, on the other hand, are used to express a sense of construction or structure, as when, for example, ammonium cyanate is resolved by heating into urea, the change may be expressed as follows:

$$CNO(NH_4) = CO(NH_2)_2,$$

in order to show that, although empirically the composition of the two substances is the same, both being concretely expressed by the formula CN_2H_4O, the molecular arrangements or structures are different.

Again, the empirical formula of ethyl alcohol is C_2H_6O, but when expressed constitutionally as $C_2H_5(HO)$, it is seen that the molecule has an alcoholic structure and that the group HO can be replaced or substituted by other groups. So also acetic acid ($C_2H_4O_2$) may be expressed constitutionally in several ways, thus:

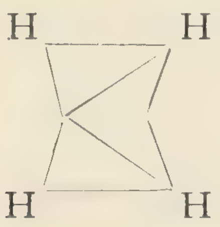


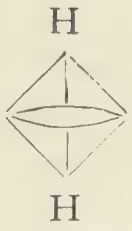
$$CH_3—C\begin{matrix}{}^{\diagup\!\!\diagup O}\\ {}_{\diagdown OH}\end{matrix}$$

—that is, carbon in association with the groupings CH_3,OH, and oxygen; otherwise as CH_3,CO,OH—that is, the radical methyl, the radical hydroxyl, and oxygen all in direct combination with carbon; or as $H(C_2H_3O_2)$—that is, as hydrogen acetate or a molecule of hydrogen in which 1 atom is replaced by the group $C_2H_3O_2$, according to the views taken of the order of arrangements of the atoms in the acetic acid molecule.

The bonds or attachments between atoms as existing in compounds are represented by dots (.) or lines (—); for example, water may be represented either as H_2O or H.O.H. or H—O—H; double and triple bonds being represented, *e.g.*, C : O and N⋮CH.

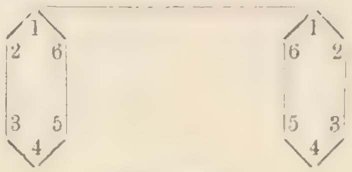
Space Formulæ are used to give a figurative view of the structure of compounds, and are chiefly employed in connection with carbon compounds; thus ethylene ($CH_2 = CH_2$) and acetylene ($CH = CH$) are figuratively shown respectively as follows:

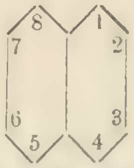




In numbering positions of characteristic radicals in substitution compounds various figures are employed, No. 1 being the significant number, as, for example:

FORMULÆ (*Continued*)—


Diphenyl.


Naphthalene.

(See E. Murgatroyd (*Chem. and Ind.*, 1927, **46**, 23); Formula Index (*J.C.S.* supplementary number, 1931, pp. 3445-3504); also Atoms, Benzene Ring, Chemical Interactions, Co-ordination, Rings, Stereochemistry, and Valencies.)

"FOURNEAU'S 309"—See "Bayer 205."

FRANGULA—See Persian Berries and Rhamnose.

FRANKINCENSE—This name is sometimes given to the oleo-resinous exudation from the spruce fir (*Abies excelsa*), from which burgundy pitch is made by melting and straining it through a cloth; but more properly relates to the gum-resin named boswellia (from *Boswellia carterii*) or olibanum. (See Gums (Olibanum).)

FRANKLINITE—An iron-manganese-zinc ore found in New Jersey, Southland (Australia), and elsewhere, having the composition (ZnFeMn)O, $(FeMn)_2O_3$, containing about 67 parts iron oxide, 17 parts manganese oxide, and 16 parts zinc oxide (crystal system, No. 1, and sp. gr. 5·0).

FRAUNHÖFER LINES—See Light (Spectroscope), p. 536.

FREEZING MIXTURES—See Refrigeration.

FREEZING-POINTS—The temperature at which liquids solidify. When cooled under pressure, liquids which yield solids of higher sp. gr. than the liquids themselves exhibit a rise in their freezing-points, while in the case of those which give solids of lower sp. gr. there is a depression. According to the law of Raoult, the freezing-point is depressed to the same extent when molecular quantities of various substances are dissolved in identical weights of the same solvent. (See H. Etherington (*Chem. and Ind.*, 1926, **45**, 430); also Melting-Points.)

FRENCH CHALK (**Steatite or Soap-Stone**)—A soft silicate of magnesium mineral, talc-like in nature, used in the engraving and litho trades, preparing size for rope and twine-making, in preparing crayons, paper-making, etc. A big deposit, which can be cut, sawn, drilled, and polished, and will absorb many colours, is located at Zwettl near the Bohemian frontier. (See Steatite and Talc.)

FRENCH POLISH—A solution of shellac in alcohol, other resins being sometimes incorporated.

FRIAR'S BALSAM—See Balsams.

"FRIARY METAL"—An alloy of calcium, barium, and lead made by an electrolytic process; stated to be particularly useful as a bearing metal.

FRIEDEL-CRAFT'S REACTION—One which, using anhydrous aluminium chloride as condensing agent, serves for the synthesis of aromatic hydrocarbon derivatives, from mixtures of hydrocarbon and

FRIEDEL-CRAFT'S REACTION (*Continued*)—alkyl or acyl halides, halogen hydride being set free. For instance, when a solution of amyl chloride in benzene is treated with the metallic chloride, hydrochloric acid is set free and amyl-benzene is formed: $C_5H_{11}Cl + C_6H_6 = HCl + C_6H_5(C_5H_{11})$. (See P. H. Groggins (*Ind. Eng. Chem.*, Feb., 1931, reproduced in *C.T.J.*, 1931, **89**, 129).)

"FRIGILENE"—A colourless, celluloid cold lacquer for preserving the polish or finish on metallic articles.

FRITS—The various materials used in compounding glass and enamels as obtained by the baking or calcination of them, but before fusion.

d-**FRUCTOSE** (**Lævulose**)—A form of crystallizable fruit sugar ($C_6H_{12}O_6$), m.p. 95° C., accompanying glucose or grape sugar in the juice of many sweet fruits and in honey. It can be prepared from cane sugar in association with *d*-glucose by hydrolysis with hydrochloric acid; also from various plant sources, including artichokes, and has been obtained in crystalline form twice as sweet as sucrose. It is fermentable, but less so than *d*-glucose; is soluble in water, alcohol, and ether, and is lævorotatory in character, while *l*-fructose is dextro-rotatory, and is not readily fermentable. (See McGlumphy and Eichinger on its commercial production from artichokes (*B.C.A.*, 1932, B, 76) and Levulose.)

FRUIT SUGAR—See Fructose.

FRUIT SYRUP INDUSTRY—See *Ind. Chem.*, 1928, iv., 279.

FRUITS AND FRUIT PULPS—There are well-known methods of preserving fruits, particularly the hard varieties, while the softer kinds can be pulped and the pulp and juice thus produced be subsequently dehydrated, giving a dry fruit powder available for use as required. Ethylene gas is used in the U.S.A. in admixture with air in proportions of about 1 to 1,000 for the preservation of fruit at between 65° and 85° F., two charges being given each day, and ventilation effected between each charge. (See H. Mansfield (*Analyst*, 1927, **52**, 351); "Composition of Fruits as used for Jam Manufacture" (*Analyst*, 1931, **56**, 35); H. Eckart on "Refractometric Studies on Fruit Juices" (*Analyst Abs.*, 1931, **56**, 461); Ministry of Agriculture and Fisheries' Statutory Rules and Orders, 1930, No. 370 (H.M. Stationery Office); Food Investigation Report No. 38 on Wastage in Imported Fruit (H.M. Stationery Office); "Gas Storage of Apples" (*The Times*, March 4, 1932, p. 11); and Citrus Fruits Industry.)

FUCHSINE (**Roseine**)—See Magenta.

FUEL—*References:* C. H. Lander (*J.S.C.I.*, 1925, **44**, 375 T); E. C. Evans (*Ibid.*, 1925, 383 T); Reports of Conferences (*J.S.C.I.*, 1926, **45**, 289-301 T, and *Chem. and Ind.*, 1931, **50**, 580); "The Behaviour of Carbonized Fuels in Open Grates," by Bligh and Hodsman (*J.S.C.I.*, 1927, **46**, 92 T), and by Milner, Dyde, and Hodsman (*Ibid.*, 1931, **50**, 113 T); review of work at the Fuel Research Station at Greenwich (*Ind. Chem.*, 1927, iii., 163); J. Roberts (*Ind. Chem.*, 1928, iv., 380); "The Reactivities of Solid Carbon on Fuel Processes," by J. W. Cobb (*Chem. and Ind.*, 1929, **48**, 90); report of lecture on "Smokeless Fuels and how

FUEL (*Continued*)—

they Burn," by H. J. Hodsman (*Chem. and Ind.*, 1929, **48,** 1110); Reports of the Fuel Research Board for the Years 1930 and 1931 (H.M. Stationery Office); "Fuel Gas (Technique)," by L. H. Sensicle (*J.S.C.I.*, 1930, **49,** 57 T); "The Fuel Technologist and Classification of Coal," by C. A. Seyler (*Chem. and Ind.*, 1931, **50,** 393); "Application of Mathematics to Fuel Problems," by J. W. Hinchley (*Chem. and Ind.*, 1931, **50,** 554); "National Fuel Problem," by H. T. Tizard (*Chem. and Ind.*, 1931, **50,** 925); *Fuel: Solid, Liquid, and Gaseous*, by J. S. S. Brame (Ed. Arnold and Co.); *Fuel*, by G. W. Andrew (E. Benn, Ltd.); *Technical Data on Fuel*, edited by H. M. Spiers; *Transactions of the World Fuel Conference* (Lund Humphries); Ashes, Berginization, Coal, Coke, Colloidal Fuel, Smokeless Fuel, Gas, Wood, and Synthol.

FUEL (Liquid)—Liquid fuels as specified below have calorific values as tabulated :

	B.Th.U. per Lb.	B.Th.U. per Gallon.
Alcohol (industrial), sp. gr. 0·822 ..	9,758	80,200
Benzene, sp. gr. 0·883	17,100	150,000
Gasolene (of flash-point = 55° F.), sp. gr. 0·704	18,500	130,240
Naphtha, sp. gr. 0·87	18,360	159,732

For other values see R. Ensoll's *Technical Chemists' Pocket-Book* (E. and F. N. Spon, Ltd., London).

The B.Th.U. per gallon of petrol, benzol, and alcohol may be roughly stated in the proportions of 14, 15, and 9 respectively. (See F. L. Nathan (*J.S.C.I.*, 1927, **46,** 212 T); "Production of Liquid Fuel from Water Gas," by R. Taylor (*Chem. and Ind.*, 1931, **50,** 580).)

In using fuel oil as a heating agent it is atomized with the necessary quantity of air to make the mixture combustible, and there are three distinct systems of application—viz., by means of compressed air (air-jet system), the steam-jet system, and the pressure-jet system, in which the oil is sprayed under pressure by means of a steam-driven pump, this latter being recognized as the most economical. In some cases powdered coal is used in association with the oil.

See Coal (p. 206), Colloidal Fuel, Methyl Alcohol, Petroleum, and Synthol.

FUEL (Powdered)—See Coal (p. 206) and *Chem. and Ind.*, 1929, **48,** 793.

FUEL (Synthetic)—See Alcohols (Methyl), Fuel, Water-Gas, Producer Gas, Synthol, and A. W. Nash (*Chem. and Ind.*, 1926, **45,** 876).

FUEL OIL—See Fuel (Liquid).

FULLER'S EARTH—A natural porous, absorptive, and colloidal aluminium silicate, containing also some magnesia and a little iron. It is of greyish, yellowish, or greenish colour, and clay-like character, widely distributed and largely produced in England, Scotland, Saxony, Bohemia, and in the U.S.A. (particularly Florida), constituting a powerful absorbent of oily matters. It is supposed to be derived from the decomposition of horn-blendes and augitics, and is prepared by

FULLER'S EARTH (*Continued*)—

drying, grinding, and sieving to the desired degree. The several varieties differ widely in specific surface, sp. gr. (from 1·7 to 2·4), adsorption power, and catalytic activities. At one time it was extensively used for "fulling" clothes, but now it is chiefly employed in connection with the bleaching and filtering of fats and oils, as a carrier of pigments, the removal of grease from woollen goods, and as a toilet article. Its bleaching action is attributed to a combination of mechanical and electrical properties, the active constituents being probably hydrated silica and hydrated aluminium silicate. The different varieties vary in their power of absorbing the same colouring matter; one variety often proves capable of bleaching one kind of material, and ineffectual in another.

The English supply of fuller's earth comes chiefly from Surrey quarries and some Somerset mines, and a large deposit occurs at Treamble in Cornwall. Extensive deposits also occur in Southern Saskatchewan (Canada), and Java, an analysis showing the latter to contain 58·6 per cent. silicic acid, 21·2 per cent. aluminium, and 3·7 per cent. lime. An analysis of the Surrey (Nutfield) earth has been given as follows: 58·66 per cent. silica, 17·33 per cent. alumina, 7·21 per cent. ferric oxide, 3·17 per cent. lime, 3·26 per cent. magnesia, 1·63 per cent. soda and potash, and loss on ignition 8·74 per cent.

Fuller's earth is liable to impart an acrid taste to oils, and is regarded as an arch-enemy to flavours and quality. The best combination has been stated to be the least possible quantity with from $\frac{1}{10}$ to $\frac{5}{10}$ of bleaching carbon. Its bleaching action on oils is the subject of a paper by Neumann and Kober (*B.C.A.*, 1927, A, 496).

A mixture of fuller's earth and sodium bicarbonate is alleged to be a good application for extinguishing petrol-store fire. (See "Adsol.")

"FULLERSITE"—Powder obtained by grinding Welsh slate waste, and used in making artificial stone, flooring material, as a filler, base for paints, oil refining, road construction in admixture with bitumen, etc. (See Roadmaking.)

FULMINATING GOLD—A compound of auric oxide (Au_2O_3) and ammonia, of explosive character, the exact chemical constitution of which has not been ascertained.

FULMINATING MERCURY (Fulminate of Mercury, Oxycyanide Pyrofulmin) ($Hg(CNO)_2$)—A crystalline poisonous compound used for priming percussion caps and in making detonators. It explodes when dry under the slightest friction, and has to be kept wet until used. It is formed as a white precipitate by heating a solution of mercury in excess of nitric acid with alcohol, and is stated to be changed into a non-explosive substance by heating to 90° C. for about 100 hours either wet or dry. The use of fulminating mercury as a detonating compound has been largely superseded by lead azide ($Pb(N_3)_2$). Its structure is discussed by F. H. Van Leent (*B.C.A.*, 1931, A, 181). (See also Laffitte and Patry (*B.C.A.*, 1931, A, 1020); Azides and Detonators.)

FULMINATING SILVER is prepared by dissolving silver oxide (Ag_2O) in strong ammonia, and is an explosive compound, possibly of the nature of a nitride (Ag_2N).

FULMINIC ACID ($HCNO$ or $C:N.OH$)—Known chiefly in its combinations, and said to be produced by the action of sulphuric acid on a solution of potassium fulminate followed by extraction with ether. It is the oxime of carbon monoxide. (See "Salts of Fulminic Acid," by Wöhler and Weber (*B.C.A.*, 1930, A, 74), and Oximes.)

FUMARIC ACID ($C_4H_4O_4$ or $C_2H_2(CO_2H)_2$) is a natural constituent of some plants, fungi, and lichens, including *Fumaria officinalis, Glaucium flavum,* and Iceland moss, and results from the fermentation of saccharine liquids containing the requisite nutrient materials, such as beer-wort, grape-juice, etc., with a pure culture of *Aspergillus javanicus* (*A. fumaricus*). It crystallizes in colourless prisms, is inodorous, has an acid taste, and is readily soluble in hot water, alcohol, and ether. It is nearly allied in constitution to maleic acid ($CO_2H.CH.CH.COH_2$), and is resolved into succinic acid by the action of reducing agents.

FUMED OAK is prepared by fumigation of the wood with ammonia, the darkening resulting from the action of that substance in association with atmospheric oxygen.

FUMIGATION—Exposure to the action of vapours or fumes, as when fumigating a room by sulphur dioxide generated from a burning sulphur candle, for the purpose of disinfection or for the destruction of bugs and other obnoxious insects, rats, etc.

The vapours of formaldehyde and paraform have identically the same value as germicidal agents when used for fumigation of rooms, and the presence of water-vapour does not facilitate the disinfection. It has also been proved that a sulphur candle of 9 ounces weight burned so as to cause the evaporation of 6 ounces of water suffices to sterilize a room of 1,000 cubic feet capacity within two hours, while 20 grms. of paraform or $1\frac{3}{4}$ ounces of 40 per cent. solution of formaldehyde are equally effective in respect of *B. typhosis*. (Kingzett, Bottomley and Brimley, *Medical Press*, August 29, 1917.)

For the fumigation of ships and rat destruction by hydrocyanic acid gas, the U.S.A. Public Health Service recommends a mixture of powdered sodium cyanide 4 ounces, sodium chlorate 3 ounces, talc 2 ounces, commercial hydrochloric acid 17 ounces, and water 34 ounces for each 1,000 cubic feet. The volume percentage used varies from 0·2 to 1·0; the time of application about 4 hours, followed by 12 to 18 hours' aeration (*Analyst*, 1924, **49**, 533). Fruit and vegetables are liable to undergo serious damage by excessive fumigation with hydrogen cyanide, and that agent is of doubtful value in controlling the infection of fruits with bacteria and moulds. Ethylene oxide, C_2H_4O (obtained by distilling glycol chlorhydrin with a solution of caustic potash), a mobile liquid of sp. gr. 0·896 and b.p. 13·5°, when mixed with carbon dioxide, has been advocated as a fumigant for the treatment of foodstuffs. The mixture is marketed in England as "Actox." (See *C.T.J.*, 1930, **86**, 329 and 477; and 1930, **87**, 386; Chlor-acetophenone, Hydrocyanic Acid, and Wheat.)

FUMING SULPHURIC ACID—See Sulphur.

FUNGI—The fungi are generally regarded as an enormously large class of plants of very low order—some 30,000 to 40,000 known species—including moulds, mildews, rusts, toadstools, puff-balls, and some microscopic forms of bacteria. So far as they initiate or take part—as they do—in respect of many chemical changes affecting vegetable life, tobacco, milk, carbohydrates, fats, etc., reference is made to them elsewhere in this work.

Moulds are minute fungi, the common white mould being the so-called *Mucor mucedo*, the bread mould is known as *Eurotium aspergillus glaucus*, and that which grows on jam and fruit as *Penicillium glaucum*. A large number of the spores of fungi are always present in the atmosphere, and, finding suitable pabulum, speedily develop into fungi, notably the spores of *Aspergillus* and *Penicillium*. The "black-spot" of cold-store meat is attributed to the fungus *Cladosporium herbarum*.

Yeasts constitute another division of fungi. Some varieties—*Dermocyte sanguinea*, for example—yield dyes to suitable solvents such as alcohol. Some papers concerning the colouring matters of fungi will be found in *J.C.S. Abs.*, cxxviii., 1925, I., 1439 and 1440; and Kögl (and associates), *B.C.A.*, 1930, A, 1581, and *Ibid.*, 1931, A, 227. A summary reference to chemical products resulting from the life history of a large number of moulds in a mineralized solution of glucose as made in the Nobel Ardeer Laboratory at the instigation of Dr. Rintoul under the leadership of Dr. Raistrick, is given by Armstrong (H. E.) (*Chem. and Ind.*, 1930, **49**, 783). In a paper by Tomkins and Woodman on "Stalk Treatment of Fruit and Vegetables for the Prevention of Stalk-Rot, with Special Reference to Bananas," the use of paraffin wax or "vaseline" for stem end treatment is recommended (*J.S.C.I.*, 1930, **49**, 286 T).

In Bulletin No. 23, published by the Ministry of Agriculture, or 3rd edit. of *Edible and Poisonous Fungi* (H.M. Stationery Office), it is stated that the kinds of fungi really poisonous and those of nutrient value are both few in number. The effect of fungi and insect pests on plant cultivation, and protection therefrom, is dealt with by T. H. Fairbrother (*Ind. Chem.*, 1927, iii., 73, 113, 174, 201, and 319); see also H. Martin on "Chemistry and Certain Problems of Applied Mycology" (*J.S.C.I.*, 1930, **49**, 11 T); *Fungus World*, by R. T. Rolfe and F. W. Rolfe (Chapman and Hall, Ltd.); *Moulds, Yeasts, and Actinomycetes*, by A. T. Henrici (Chapman and Hall); Decay, Fermentations, Insecticides, Lichens, Mildew, and Yeasts.

FUNGICIDES—See Insecticides and Fungi.

FUNNELS—See Filters.

FUR—See Hair.

FURANE (Furfurane) (C_4H_4O) is a colourless mobile liquid with an odour like chloroform, b.p. 32° C., contained in pine-wood tar, and the products of the distillation of sugar with lime. (See Furol.)

FURNACES, as used in laboratories, are of various descriptions. Electrical furnaces are only to be found in highly equipped establishments,

FURNACES (*Continued*)—

and some references to their industrial applications will be found elsewhere. (See Electricity, p. 296.) The "Ajax-Northrupp" high-frequency induction furnace (introduced to replace the crucible furnace for manufacturing alloy tool steels) is used in small sizes for melting up to 100 ozs. of platinum, etc. (See S. J. Hewitt, *Ind. Chem.*, 1928, iv., 19.) There are many other varieties of furnaces used in chemical industry, including some with fixed hearths, in which the ore or other material is rabbled with mechanical arms; others of a vertical or cylindrical type, others again with revolving hearths; rotary furnaces such as those used in cement making; muffle furnaces, such as those used for roasting zinc blende; "shaft" furnaces used for the chloridizing of silver ores; blast furnaces (some water-jacketed); reverberatory furnaces, etc. In some, the air for burning the fuel passes through the fire-bed, while reverberatory furnaces are so constructed that the fuel flame, before passing to the chimney-shaft, is made to pass (reverberate) over the materials lying upon the bed, these materials being the substances to undergo chemical change by action of the heat thus imposed.

References: Mechanical furnaces and their uses in roasting certain ores (discussion) (*C.T.J.* of April 10, 1925); "Furnace Insulation," by A. E. Hubbard (*Ind. Chem.*, 1930, vi., 465); a large mechanical roasting furnace is described and illustrated (*Ind. Chem.*, 1929, v., 435); automatic combustion control for boiler furnaces is the subject of articles (*Ind. Chem.*, 1929, v., 27), and by T. R. Alexander (*Ibid.*, v., 29); "Combustion in Flues and Furnaces," by J. W. Cuthbertson (*J.S.C.I.*, 1931, **50**, 451 T); the design and operation of gas-heated furnaces by C. M. Walter (*Chem. and Ind.*, 1929, **48**, 954); "Electric Furnaces for Heat-treatment," by A. G. Lobley (*Chem. and Ind.*, 1930, **49**, 141); "Laboratory Furnaces for High Temperature Work," by N. R. Davis and C. Sykes (*Chem. and Ind.*, 1931, **50**, 506); and W. Adam (*B.C.A.*, 1930, B, 671); *Industrial Furnace Technique*, by A. Hermansen (Ernest Benn, Ltd.); Heat, and Organic Analyses.

FUROL or FURFUROL (**Furfural, Furfuraldehyde**) ($C_5H_4O_2$ or $(CH)_3$ OC.COH) when freshly distilled is a colourless, inflammable, volatile, aromatic liquid contained in the products obtained by distilling sugar, wood, or bran with moderately strong sulphuric acid, and can indeed be obtained from straw, oatmeal, jute, certain gums, and any other materials containing pentosans, but oat-hulls and corn-cobs appear to be the best sources, the former yielding some 12 per cent. or more when subjected to the action of steam in rotary digesters, the furfurol being recovered from the distillate. The yield being quantitative, the method of production has been used to determine the amounts of pentoses contained in various materials. Air-dried Japanese rice bran is stated to yield from 9 to 10 per cent.

Industrial processes by means of hydrolysis, both with and without acids, are in course of development; wood waste and other materials yielding the product when treated with high-pressure steam in the presence of hydrochloric, sulphuric, or sulphurous acids, with or without the use of certain metals or metallic oxides as catalysts.

FUROL or FURFUROL (*Continued*)—

It turns amber to reddish-brown upon exposure to light and air, has a sp. gr. of $1{\cdot}1598\frac{20}{4}$ and $1{\cdot}1545\frac{25}{4}$; b.p., 161·7° C. at 760 m.m.; f.p., −36·5° C.; flash-point, 55 to 57; and ref. ind., n^{20}_{D} $1{\cdot}52608^{16}$.

Furfurol is soluble in water to the extent of 8·3 per cent. at 20° C., and water is soluble in furfurol to the extent of 4·8 per cent. at the same temperature. It is completely miscible with alcohol, ether, acetone, and benzol, but only slightly soluble in the petroleum hydrocarbons.

It is an excellent solvent for cellulose nitrate and acetate; is used in the lacquer industry and to some extent as a base-dye, several colours being prepared from it by condensation with aromatic amines.

By treatment with amines and phenol, it yields a synthetic resin, which is very hard and flexible, and is soluble so far as known in "tetralin" only; and this product seems likely to be of considerable service as an electrical insulating material and for other applications.

Furfurol can be used as a motor fuel and as a substitute for or in conjunction with formaldehyde in the preparation of synthetic resins and moulding compounds; also by reason of its germicidal character as a preservative of adhesive pastes and biological specimens, and may find some use as a substitute for turpentine in varnish manufacture, also as a substitute for formaldehyde in tanning.

Some of its derivatives, such as hydrofuramide ("Vulcazol"), furfurin, dithiofuroic acid and its salts, are used as rubber accelerators.

References: Some fuller details concerning Furol and its industrial applications by T. H. Barry (*Ind. Chem.*, 1930, vi., 479); H. J. Brownlee (*B.C.A.*, 1927, B, 346); *C.T.J.*, 1926, **78,** 407; Routala and Kuula (*B.C.A.*, 1930, B, 278); D. H. Killifer (*B.C.A.*, 1927, B, 92); B. Groth (*B.C.A.*, 1931, A, 574); and Pectins.

FUSAIN—See Coal, p. 203.

FUSEL OIL—A by-product from the distillation of alcohol produced by fermentation (particularly that from potato starch), consisting largely of butyl and iso-amyl alcohols (the last named amounting to from 50 to 80 per cent.), together with some aldehydes, esters, and other substances, including pelargonic and capric acids, and a small amount of furfurol. As generally produced it contains ethyl alcohol as an impurity. It boils at from 80° C. upwards, but chiefly between 128° and 132° C.; has a density of 0·83; is of unpleasant odour and taste, and on account of its objectionable qualities it is of importance to remove it from spirits intended for consumption. It is used in the preparation of amylic alcohol, lacquers, and varnish-making. In an investigation by A. C. Chapman of a Yugoslavian fusel oil, resulting from the fermentation of molasses, it was found that the basic constituents of a high-boiling fraction consisted mainly of trimethylpyrazine and tetramethylpyrazine, together with small quantities of other substances. A method for the separation of fusel oil during rectification, etc., is described by B. Lampe (*B.C.A.*, 1930, B, 164 and 436); see also Amyl Alcohol.

FUSES—See Detonators.

FUSIBLE METAL is an alloy, the melting-point of which largely depends upon the proportion of bismuth employed (generally about 50 per cent.), with lead about 20 per cent., tin 12 to 13 per cent., and cadmium about 12 to 13 per cent. One variety has a fusing-point of 67·5° C., and is used for producing casts of metals, solders, in stereotyping, and in making safety-valves for boilers, fusible plugs, valves, etc. (See Alloys and Bismuth.)

FUSION—The liquation, or melting into the fluid state, of solids by means of heat. The temperatures at which this liquation takes place are called the fusing or melting-points. (See Liquation, Melting-Points, and Metals.)

FUSTIC EXTRACT (**Cuba Wood**) is the name of a yellow dye of two varieties—viz., "old fustic," obtained from yellow Brazil wood (*Morus tinctoria* or *Chlorophora tinctoria*, Gaudich), which is found also in Mexico and the W. Indies and used for dyeing wool mixed shades; and "young fustic," from *Rhus cotinus*. The colouring matter itself is named *fustin*, and is used in the textile and leather industries. (See Morin and Sumac.)

G. SALT—An intermediate, being the sodium salt of amino-naphthol disulphonic acid (H acid).

GADOLINITE—A complicate silicate mineral found in Norway and Sweden (known also as yttrite and ytterbyte) of black, brown, and yellow colour, containing glucinum, lanthanum, and the rare earths yttria, ceria, etc.; also found in pegmatites in Arizona, Colorado, and Texas (crystal system, No. 5, and sp. gr. 4·3).

GADOLINIUM (Gd)—Atomic weight, 157. A very rare and but little known element of the terbium group, found present in *samarskite, orthite, cerite,* etc. An oxide, Gd_2O_2, is known.

GAFSA PHOSPHATE—See Phosphorus and Sodium (Hydrogen Sulphate, p. 831).

GAHNITE (**Zinc Spinnelle**)—A natural zinc aluminate (ZnO,Al_2O_3), of crystal system, No. 1, and sp. gr. 4·0 to 4·6. (See Zinc.)

GALACTOSE ($C_6H_{12}O_6$)—A colourless, crystalline carbohydrate (saccharose), prepared by oxidation of dulcitol and identical with the sugar named cerebrose by Thudichum; soluble in water, and melts at about 170° C. There are probably four modifications of galactose, of which two have been isolated.

GALACTOSIDES—A group of substances, including phrenosin and kerasin, occurring in brain-substance, analogous in constitution to the vegetable glucosides, and which yield acids, sphingosine, and galactose upon hydrolysis.

Phrenosin yields phrenosinic acid ($C_{25}H_{50}O_3$), sphingosine ($C_{17}H_{35}O_2N$), and galactose when thus treated, and kerasin yields lignoceric acid ($C_{28}H_{48}O_2$), as also sphingosine and galactose. (See Thudichum's *Ann. Chem. Med.*, vol. 1, pp. 17 and 18, and vol. 2, p. 12 (Longmans and Co); and O. Rosenheim, *J. Biol. Chem.*, vol. 7, no. 6, December, 1913; vol. 8, no. 2, April, 1914, and vol. 10, no. 1, March, 1916.)

GALANGA ROOT—The rhizome of *Alpinia officinarum* (Hance), contains a flavonol named galangin, which has also been synthesized. (See Flavone.)

GALBANUM—See Gums.

GALENA—Mineral lead sulphide, of crystal system, No. 1, and sp. gr. 7·0 to 7·5. (See Lead.)

"GALILITH"—A plastic product or synthetic resin made from casein by hardening with formaldehyde, and used in making buttons and cheap combs, etc. It has a sp. gr. 1·34, a hardness of 2·5, resists acids, oil, alcohol, and benzene, but is attacked by alkalies, and absorbs water when immersed for long periods.

GALIPOT—A French name for resin from the *Pinus maritima*. (See Turpentine.)

GALLIC ACID (Trihydroxy-Benzoic Acid) ($C_7H_6O_5$ or $C_6H_2(OH)_3CO_2H$) occurs in catechu, kino, coffee, nut-galls, sumach, tea, and a number of tannins in the form of glucosides from which it can be made by boiling with acids, or by moulds acting on solutions of tannin. The fermentation process of manufacture is referred to in a paper by May and Herrick (*Ind. and Eng. Chem.*, November, 1930). In the pure state it crystallizes in nearly colourless silky needles of the composition $C_7H_6O_5,H_2O$, and is soluble in water, ether, and alcohol. With ferrous sulphate it gives a brown colour, which quickly blackens on exposure to the air, and it is used in photography, dyeing, and the manufacture of pyrogallol and ink.

A commercial gallic acid is prepared of from 55 to 58 per cent. strength. (See Inks, Tannase, Tannic Acid and Tannins.)

GALLIPOLI OIL—See Olive Oil.

GALLIUM (Ga) **and its Compounds**—Atomic weight, 69·72; sp. gr., 5·95; m.p., 30·2° C.; b.p., about 2,000° C.; said to exhibit two isotopes. It is a rare, grey, lustrous metal occurring in very minute amounts in certain clay ironstones and specimens of zinc blende from the Pyrenees, also in *germanite*. Little is known about it beyond its spectroscopic character. It combines rapidly with chlorine, is soluble in warm hydrochloric and nitric acids, and forms an alloy with aluminium. It decomposes water at high temperatures, and its compounds (including an oxide, Ga_2O_3, and sulphate, $Ga_2(SO_4)_3 18H_2O$, resemble those of aluminium. It does not solidify at 20°, and this property is utilized by its employment in the construction of quartz thermometers for taking temperatures above 500° C. (See Thermometers and E. R. Berry (*Chem. and Ind.*, 1926, **45**, 35).)

GALL NUTS are produced as excrescences on the leaves (and their stalks) of the oak (*Quercus infectoria*) by punctures of gall-wasps (*Cynips gallæ tinctoriæ*), in which they lay their eggs. The Aleppo galls are most valued, but although those from the Levant (containing about 60 per cent. tannin) are the best, there are others of inferior quality which

GALL NUTS (*Continued*)—
come from Dalmatia and other places, including the province of Hunan in China. They contain gallo-tannic acid or other tannins, some of which compounds are also present in sumach and tea, and are used in tanning, also in the manufacture of blue-black ink, for the production of certain tints in Turkey-red dyeing and in calico-printing. (See also Myrobalans and Inks and Tannins.)

GALLO-TANNIN—See Gallic Acid, Tannase, Tannins, and Tannic Acid.

GALVANISM—See Electricity.

GALVANIZING—Coating iron with zinc by immersion in the molten metal, after suitable preparation by cleansing and sprinkling with sal-ammoniac, etc. The cleansing (pickling) is carried out by immersion in, or scrubbing the metal with, dilute hydrochloric or sulphuric acid and sand, so as to remove adherent impurities and to produce smoothness of surface. (See H. Bablik, *B.C.A.*, 1926, B, 443.) The formation of blow-holes in steel after pickling is attributed to the absorption of hydrogen from the action of the acid on the metal, and this action is the greater the thinner is the sheet. (See Bardenheurer and Thanheiser, *B.C.A.*, 1929, B, 818.)

The thickness of the coating depends largely on the intensity of the reaction, and on the viscosity of the bath, low temperatures (420° to 450° C.) favouring the formation of thin coatings, and a small addition of aluminium (up to 0·63 per cent.) increasing the fluidity of the bath. Sometimes 1 per cent. tin is also added, and with such a mixture the zinc taken up amounts to about 500 to 600 grms. per sq. m. The life of galvanized sheets depends directly upon the purity of the iron or steel used, and the coating itself is stated to consist of about 89 per cent. zinc and 11 per cent. iron.

Cold galvanizing is carried on commercially by the electrolysis of zinc sulphate solution, using a zinc anode. (See *Ind. Chem.*, 1926, ii., 412.)

T. Lewis Bailey and E. Linder have shown that 0·1 per cent. ordinary size (glue) added to the pickling bath acts as an excellent restrainer, reducing iron loss and acid consumption.

It has been computed that one-half of the total zinc production is used in galvanizing. The recovery of valuable materials from galvanizers' by-products is the subject of a paper by N. F. Budgen (*Ind. Chem.*, 1927, iii., 55); see also H. Kurrein (*B.C.A.*, 1931, B, 444),and Metals (Calorizing and Sherardizing).

GALVANOMETER—Instrument for measuring electrical currents. (See *Chem. and Ind.*, 1932, **51,** 184.)

"GALVENE"—A proprietary "inhibitor" or "restrainer" used in acid pickling baths for cleaning metal surfaces.

GAMBIER—The inspissated juice (catechu) of two plants (*Uncaria gambier* and *Mauclea*), which grow in the Dutch Indies, principally Sumatra and Java; principally imported from Singapore, and used in dyeing, silk weighting, and tanning. (See Eaton and Bishop, *B.C.A.*, 1927, B. 230.)

GAMBOGE—See Gums, p. 425.

GAMMA ACID—See Acid G.

GAMMA RAYS—A form of X-rays. (See Radio-activity and Wave Lengths.)

GANGUE—The mineral matter enclosing or intimately associated with metallic and other ores.

GANISTER—A highly refractory, close-grained, siliceous, sedimentary rock, found underlying some coal seams; used for making fire-bricks and for lining blast and other furnaces. The mixture generally used consists of the silica mixed with one-tenth its weight of clay. (See Refractories.)

GARJAN OIL (Kenyensi)—A drying oil available in Burma for use instead of boiled linseed oil in making printing inks, etc.

GARLIC OIL—Distilled from *Allium sativum,* a genus of Liliaceæ, comprising garlick, leek, onion, shallot, and chive; is of pale yellowish colour and penetrating odour, containing several allyl sulphides, including $(C_3H_5)_2S$. It has a sp. gr. of 1·05, is soluble in alcohol, ether, etc., and is used in medicine and for flavouring.

GARNET (Carbuncle)—Name of a variety of cubical minerals (*almandite, andratite, essonite,* etc.), of crystal system, No. 1, and sp. gr. 3·4 to 3·8, of varying colours, consisting of double silicates of various bases, including alumina (many good supplies of which are found in Canada), and utilized to some extent as a wood abrasive. The precious garnet is the variety known as *almandite* or *almandine* ($6FeO,3SiO_2 + 2Al_2O_3, 3SiO_2$). In some varieties the iron oxide is replaced by lime, manganese oxide, and magnesia respectively, while others contain ferric oxide (Fe_2O_3) and chromium as Cr_2O_3 in more or less corresponding combinations. Supplies of different varieties come from Bohemia, Ceylon, Brazil, and Syriam (the source of the esteemed Syrian garnets).

GARNIERITE—See Nickel.

GAS (Coal)—The composition of coal gas as produced for illuminating purposes depends very largely upon the kind of coal used, temperature at which the roasting of the coal takes place, the construction of the retorts, and the amount of air that gains access to the retorts. The temperature ordinarily observed is from 2,000° to 2,200° F. It contains not only permanent gases, but, in addition, considerable quantities of the vapours of volatile hydrocarbons, to which its luminosity when burning is due. The greater proportion consists of hydrogen (about 35 to 50 per cent.), which burns with a practically colourless flame, and marsh gas or methane (CH_4) (about 35 to 40 per cent.), which also gives but little light when burned alone. Among the constituents there are proportions of carbon dioxide, carbon monoxide, nitrogen, oxygen, hydrocyanic acid, carbon disulphide, and hydrogen sulphide.

There is a process for removing these two last-named impurities by passing the gas through a solution of sodium polysulphide, which, becoming saturated with ammonia, converts the hydrocyanic acid into

GAS (Coal) (*Continued*)—

ammonium sulphocyanide. The carbon disulphide can also be removed by passing the gas over heated nickel, the products being mainly carbon and hydrogen sulphide.

The purification of coal gas from hydrogen sulphide, hitherto generally accomplished by the use of hydrated ferric oxide, can also be effected by the "Koppers" Company liquid method, which consists of the use of a dilute solution (1 to 3 per cent.) of sodium carbonate and is largely used in America. (See R. H. Clayton (with others), *B.C.A.*, 1932, B, 52; Gluud and another, *B.C.A.*, 1927, B, 321, and L. A. Sayce, *J.C.S.*, 1929, p. 2002.) The hydrogen sulphide is removed from the solution and the sodium carbonate regenerated for use over and over again by blowing air through it in another tower, sulphur being liberated at the same time and subsequently collected and purified. Practically from 90 per cent. to all the hydrocyanic acid contained in the gas is converted into thiocyanates. It is usually preferred to remove some 85 to 90 per cent. in this way, the remaining quantity being taken out in the iron oxide catch boxes.

According to the Report of the Fuel Research Board for period ended December 31, 1924, in low temperature carbonization about three-quarters of the weight of coal remains as coke, and 1 ton of average coal carbonized at about 600° C. in externally heated retorts produces about 3,000 cubic feet of gas of a calorific value 700 to 1,100 B.Th.U. per cubic foot, the amount being generally equivalent to 30 to 35 therms, or about 10 per cent. of the heat value of the coal, and analyses of gases from typical coals are given in the following table. (See Coal.)

Type of Coal (Bituminous).	Strongly Caking.	Medium-Caking.	Non-Caking.	Medium Caking Blend.
CO_2,H_2S, etc. ..	5·4	7·1	11·1	7·2
C_nH_n	11·5	8·6	9·4	9·6
O_2	1·8	1·3	1·7	1·9
CO	5·0	5·4	7·1	7·1
H_2	15·7	16·0	17·6	15·0
$C_nH_{2n}+2$	49·8	52·4	41·8	48·3
N_2	10·8	9·2	11·3	10·9
	100·0	100·0	100·0	100·0

The saturated hydrocarbons consist chiefly of methane, and the value of *n* in $C_nH_n2_{n+2}$ is about 1.25. Light spirit for making motor fuel can be recovered by scrubbing to extent of about $1\frac{1}{4}$ gallons per ton of coal used.

The trouble caused by the deposition of naphthalene in the mains and services can be obviated by washing the coal gas with creosote oil, which is capable of absorbing about 12 per cent. of that substance, while any water that is present can be and is, generally speaking, removed by the use of solid or liquid absorbent agents.

The illuminating power of coal gas is chiefly attributable to olefiant

GAS (**Coal**) (*Continued*)—

gas and other associated hydrocarbons, which, in all, amount to about 5 per cent., and the process of roasting the coal is conducted in such a way as to yield about 10,000 cubic feet of gas per ton of coal.

Apart from economical considerations, town gas is the best fuel yet available for use in certain classes of internal combustion engines.

The quantity of British gas made in 1926 was 296,082 million cubic feet.

The composition of good coal gas according to one analysis, which is fairly representative, of old-time supplies was as follows:

Hydrogen	48·2	per cent.
Methane	34·2	,,
Carbon monoxide	6·6	,,
Olefines and benzene	5·3	,,
Nitrogen, carbon dioxide, and oxygen	5·7	,,
	100·0	

The gas, however, now generally supplied consists of a mixture of ordinary coal gas with from 15 to 33⅓ per cent. of so-called water gas, or carburetted water gas—that is, the mixture of carbon monoxide and hydrogen which is produced by passing steam over red-hot coke, while at the same time a certain quantity of petroleum is introduced and destructively decomposed or "cracked" in the furnace, to give to the other gases that proportion of hydrocarbons necessary to give luminosity to the whole mixture when it is burned.

The effect of using too much water gas is to introduce more carbon monoxide than is desirable, as it contains about 42 per cent. of that poisonous compound, and complaints have been made that whereas the old-style coal gas contained only about from 6 to 8 per cent., the newer supplies contain much more (15 to 20 per cent.). (See "Carbon Monoxide and Gas Poisoning" (*Chem. and Ind.*, 1930, **49**, 195).)

There is a well-known process of converting this monoxide into carbon dioxide, which consists of passing the gas over an iron oxide catalyst at a fairly high temperature, so that it can be reduced to less than 1 per cent., the carbon monoxide interacting with the moisture to form carbon dioxide and hydrogen, the carbon dioxide being subsequently washed out. This method is reported to largely increase the percentage of hydrogen, and yields a good smokeless fuel.

Another process, in which the carbon monoxide reacts with steam and hydrogen, uses a nickel-thoria catalyst, at an elevated temperature, yielding methane and carbon dioxide, thus improving the lighting quality without diminishing the quantity of coal gas produced.

When coal gas is submitted to a pressure of 150 lbs. per square inch, liquid hydrocarbons are produced, which are separable to some extent by fractionation, and one of the fractions can be used as a motor spirit of high volatility and great propellent power, but, apart from its cost, it shows a tendency to resinify.

The carbonization of coal for the production of gas, etc., is the sub-

GAS (**Coal**) (*Continued*)—

ject of a publication by West's Gas Improvement Co., giving the results obtained by using Glover-West vertical retorts (Manchester).

References: "Solvents from the Gas Industry," by C. R. Downs (*Chem. and Ind.*, 1932, **51**, 28); "Phenol Recovery from Gas Liquor" (*C.T.J.*, 1931, **88**, 274); "Steaming in Continuously Operated Vertical Retorts," by M. Barash (*Ind. Chem.*, 1926, ii., 351); "The Fundamentals of Low-Grade Gas," by N. Swindin (*Ind. Chem.*, 1929, v., 319 and 529); "The Treatment and Disposal of Gas-Liquor Effluents" (*Gas J.*, 1930, **192**, 730; *C.T.J.*, 1931, **88**, 149); A. Parker (*Ind. Chem.*, 1928, iv., 107, in which the gas yielded from coke-ovens is also referred to); "The Utilisation of Gas as a Fuel," by C. A. Masterman (*Chem. and Ind.*, 1931, **50**, 577); W. J. A. Butterfield (*J.S.C.I.*, 1927, **46**, 399 T); Coal, Coke-Ovens, Gas-Producers, Hydrocarbons, Methane, Mond Gas, Producer Gas, and Water Gas.

GAS ANALYSIS—See Burette; also the *Ind. Chem.*, 1925, i., 109, and 1928, iv., 388, in which new forms of apparatus are illustrated.

GAS BURNERS—See Burners.

GAS (**Coke Ovens**)—See Coke Ovens.

GAS FLOW—See Recorders.

GAS FUEL—See Fuel, Gas, Gas Producers, Producer Gas, and Water Gas.

GAS GENERATORS—There are many forms of laboratory gas generators, ordinary bottles and Woulfe's bottles properly fitted up being used as containers of the necessary materials; also ordinary or Florence flasks when it is necessary to employ the agency of heat.

Kipp's apparatus is designed for the generation of hydrogen sulphide (sulphuretted hydrogen), carbon dioxide, etc., in gaseous form. It is made of glass, and consists of sections for containing the acid and the iron sulphide or marble as the case may be respectively. An abstract description of a simplified gas generator is given in the *Ind. Chem.*, 1926, ii., 186, and one for delivering gas at a constant pressure by T. Gray in *J.S.C.I.*, 1928, **47**, 187 T. (See Woulfe's Bottles.)

GAS MANTLES of incandescent character are prepared from ramie yarn, silk substitutes, and other materials, by impregnation with mixtures of thoria and ceria—the rare earths which are found in monazite sand and some other minerals. After impregnation with the necessary chemicals, the mantles are lightly coated with collodion solution to give strength to the texture.

The impregnation is ordinarily effected by soaking the mantles in a solution of thorium and cerium nitrates in the proportion of 99 to 1, other substances being sometimes introduced for specific reasons, after which, and before coating with collodion, they are dried and ignited to burn off the fibre and cause the deposition of the oxides (thoria and ceria) from the nitrates on the ash skeletons of the mantles. The gas mantle at its lowest efficiency renders it possible to obtain fifteen times the light obtainable from any quantity of gas stripped of its cyclic hydrocarbons. (See Incandescence and Monazite Sand.)

GAS (Natural)—Natural gas is a mixture of hydrocarbons associated with petroleum deposits found in many parts of the world, including Transylvania and the U.S.A. (where it has been utilized for the production of finely divided carbon, ethylene dichloride, pentasol, gasoline, and extraction of helium, etc.), and parts of Canada, particularly Alberta and Ontario, 17,000,000 thousand cubic feet having been produced in these two provinces in 1925. It can be carried to distant places by piping, the propane and butane being preferably scrubbed out previously and used to enrich water gas. A scheme has recently been adopted in Canada for storage of enormous quantities of natural gas (previously wasted) by adsorption in the depleted sands of districts which have become worked out as economic petroleum-producing areas, the gas being conveyed by pipe-lines. Its uses as a raw material in chemical manufacturing is dealt with by R. T. Elworthy (*Ind. Chem.*, 1928, iv., 275); the production of solvents from the same source is the subject of an article by H. S. Garlick (*Ibid.*, 363); and analyses are to be found in papers by K. Stockfish (*B.C.A.*, 1928, A, 1349) and E. H. Boomer (*B.C.A.*, 1930, B, 227). A British source of supply is said to exist at Cymmer, Porth, Glamorganshire, showing 97·19 per cent. of combustible gas, practically all methane (*C.T.J.*, 1929, **85**, 599).

GAS PRODUCERS—There are several forms of industrial gas producers (see Producer Gas), but in that form known as the "suction" gas plant anthracite is the fuel that is used, and this is placed in a cylindrical furnace (producer), air and steam being admitted below the burning fuel. The atmospheric oxygen first combines with the burning carbon to form carbon dioxide, and this, in passing through the red-hot mass, is converted into carbon monoxide. The steam is also decomposed to some extent, forming more carbon monoxide and hydrogen gas, both of which are combustible, and together with the residual nitrogen of the air constitute a "water gas" of high calorific value. This is washed and cooled in a scrubber before being sucked in by the piston of the engine.

Coke and peat can be employed in the place of anthracite.

Suction gas made as described has an approximate composition as follows, and a calorific value of about 140 B.T.U. per cubic foot:

Carbon monoxide	18·6 per cent.
Hydrogen	17·6 ,,
Methane	1·6 ,,
Carbon dioxide	7·2 ,,
Nitrogen	54·4 ,,
Oxygen	0·6 ,,
	100·0

Mr. T. R. Wollaston has described an improved type of gas producer, in which the fuel before dropping into the producer is, while spread out in thin layers and kept in motion, subjected to a heating process by contact with the outgoing producer gas, which picks up the more volatile constituents (distillates), becoming enriched thereby, and leaves the fuel of such size and nature (irrespective of its original character) as to be

GAS PRODUCERS (*Continued*)—

readily workable at very high rates. (See T. R. Wollaston, *C.T.J.*, 1925, **76,** 4, and *Mechanical World Year Book,* 1932, p. 143 (Emmott and Co., Manchester).)

Gas produced as described, in common with coal gas, is used industrially on a very large scale, and an account of some of these applications is given in the *Ind. Chem.*, 1925, i., 191; see also *Industrial Gases,* by H. C. Greenwood (Baillière, Tindall and Cox), and Water Gas.

GAS PRODUCTION FROM HEAVY FUEL OILS—Heavy bunker oils of 950 sp. gr. and upwards are not altogether satisfactory for use in high-compression engines, hence many attempts have been made to convert such oils into producer gases by partial combustion. The "Dayton" process is among these, and the "Hakol" gas plant one of the commercial installations, carbon black being produced as a by-product. (See *Chem. and Ind.*, 1925, **44,** 479.)

In his article on this subject (*J.S.C.I.*, 1925, **44,** 299 T), J. E. Hackford shows that the yield under the described circumstances with a "Hakol" generator varies with the sp. gr. and calorific value of the oil, a heavy bunker oil only yielding 96 cubic feet to the 1 lb. of the 160 B.Th.U.: Diesel oil of *d* 0·900, 100 cubic feet; and gas oil up to 120 cubic feet. (See Producer Gas and Water Gas.)

GAS REACTIONS (Technical)—From the investigations of J. Hargreaves and F. Hurter it has been concluded that if in a process it is not essential that a definite rate of flow should be observed, it is immaterial whether that flow goes upwards or downwards; but, on the other hand, in cases where a fixed or low speed of gas movement is essential the gas should be led in downwards if regularity in the process be desired, and that it is safer in all cases to do this when the action is not endothermic. The principal obstacle to uniformity of working pneumatic processes is due to temperature differences; hence the importance of ensuring that any plant should be as uniformly heated as possible. (See *C.T.J.*, 1929, **85,** 440; also Gases.)

GAS RECORDERS—See Gases and Recorders.

GAS RESIDUALS—Board of Trade returns show that in all authorised gas undertakings in Great Britain in 1929 the residuals amounted to 12,033,000 tons coke and breeze, 215,138,000 tons tar, and 128,686 tons of ammonium sulphate.

GAS WASHING—The quantity of a gas dissolvable by a given volume of a liquid at a constant temperature is proportional to the pressure of the gas. As stated by J. Brown in his article on this subject (*J.S.C.I.*, 1925, **44,** 410 T), the solvent can absorb the gas until the vapour pressure of the gas in solution equals the partial pressure of that in the gas entering the washing apparatus. The chemical plants known as the "Gay-Lussac tower" and "Glover's tower" are referred to in describing the manufacture of sulphuric acid (see Sulphur, p. 877).

The "Pumping of Gases" is dealt with by S. G. M. Ure (*Ind. Chem.*, 1926, ii., 521), and an article on the design and operation of gas

GAS WASHING (*Continued*)—

scrubbing towers, by H. D. H. Drane (*J.S.C.I.*, 1925, **44,** 329 T). (See also Bubbler, Hydrochloric Acid (p. 185), Tower Fillings, and Waste.)

GASES—In addition to the rare elements contained in the air (see Air), five of the better-known ones exist ordinarily in the gaseous state—viz., hydrogen, oxygen, nitrogen, chlorine, and fluorine.

Gases vary greatly in their general properties—viz., colours (although mostly colourless), densities, solubilities in different fluids and chemical affinities. They can all be reduced to the liquid and solid states by lowering the temperature and increasing the pressure sufficiently, and the highest temperature at which a gas can be liquefied by compression is called its "critical temperature," while the "critical pressure" is that under which it can be liquefied at its critical temperature.

Many gases are readily absorbed by charcoal, and some of them are occluded by metals. (See Palladium and Occlusion.) Recently heated beechwood charcoal will absorb, by what is called "surface action" (see Adsorption under Colloid Chemistry), 90 times its own volume of ammonia, while that from cocoa-nut shell will take up 171 volumes. The gases most easily liquefied are those which are most readily absorbed by charcoal, and in this condensed (or maybe partially liquefied) form they exhibit unusually active chemical properties. For example, powdered charcoal saturated with hydrogen sulphide, when brought into contact with oxygen, bursts into combustion owing to the rapid chemical interaction of the two gases. The heat of absorption of various gases by coal and charcoal at 0° has been measured by A. G. R. Whitehouse (*J.S.C.I.*, 1926, **45,** 13 T).

Information concerning the surface combustion of gases arising from a self-burning mixture (as with a Bunsen burner), or when they pass through a porous diaphragm under some pressure or impinge on a refractory material, thereby caused to glow, is given by T. G. Tulloch (*J.S.C.I.*, 1926, **45,** 280 T).

Equal volumes of gases at the same temperature and pressure contain an equal number of molecules, and the volume occupied by a given weight of any gas is inversely as the pressure.

The densities of the gaseous elements are, for the most part, identical with their atomic weights (phosphorus and arsenic are two of the most noticeable exceptions, their vapours possessing a density twice as great as that required by the general law).

The densities of compound gases are one-half of their molecular weights. (See Vapour Densities.)

One litre of hydrogen at 0° C. and 760 mm. mercury weighs 0·08936 grm., and 1 grm. measures 11·12 litres, the grm. molecule measure being therefore 22·24 litres, that also being the measure of the grm. molecule of all gases at normal temperature and pressure, while the weights of litres of other gaseous elements are ascertained by multiplying this factor by their atomic weights.

Gases expand $\frac{1}{273}$ part of their volume at 0° C. for every increase of 1° C. in temperature at constant pressure.

GASES (*Continued*)—

Gas.	Critical Temperature.	Critical Pressure (Atmospheres).	Boiling-Point under 760 mm. Pressure.
Acetylene	35·5° C.	61·5	– 83·6° C.
Ammonia	132·9°	112·3	– 33·46°
Carbon dioxide	31·0°	72·9	– 80·0°
Carbon monoxide	–139·5°	35·5	–190°
Chlorine	141·0°	83·9	– 33·7°
Ether	190·0°	—	34·9°
Helium	–267·75°	2·75	–268·7°
Hydrogen	–241·0°	19·4	–252·5°
Hydrogen chloride	51·4°	81·6	– 83·0°
Hydrogen sulphide	100·4°	89·1	– 61·8°
Methane	– 82·8°	45·6	–164°
Nitric oxide	– 93·5°	71·2	–149·9°
Nitrogen	–145·0°	33·6	–195·5°
Nitrous oxide	36·5°	71·7	– 89·8°
Oxygen	–118·8°	50·8	–182·9°
Sulphur dioxide	157·2°	77·7	– 10·1°
Water*	364·0°	195·0	200·0°

Gases exhibit a peculiar property of diffusion, so that if two vessels containing, say, oxygen and hydrogen respectively, be placed with their openings in contact, each gas will mingle with the other automatically and so thoroughly that after a time there is uniformity of composition of the gases contained in the several vessels.

The rates of diffusion of gases are inversely proportional to the square roots of their densities. (See Diffusion.) This diffusion is readily appreciated if it be borne in mind that gaseous matter is to be regarded as an aggregation of molecules in which the attractive force which unites them is reduced to a minimum because the spaces they occupy are relatively great, and that these molecules, which have a natural tendency to expand, are therefore in a constant state of rapid motion and bombardment—a state of things that is of course greatly enhanced by the application of heat. It is this bombardment that is ordinarily regarded as the foundation of the pressure or elastic force (kinetic energy), exercised by gas confined in a vessel at any given temperature and pressure. Equal volumes of different gases at the same temperature and pressure exhibit identical elastic force upon the containing vessel; in other words, the kinetic energies of their volumes are the same, and as equal volumes of gases contain the same number of molecules, which vary in weight, the kinetic energy of these molecules must be identical. From these considerations it follows that the mean velocities of the molecules of varying gases must vary, and these rates are pro-

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* F. L. Teed is of opinion that the "critical temperature of water is most likely not an absolutely fixed temperature, but, like the critical temperature of fusion of ice, is a function of the pressure, only more so than in the case of ice" (Teed's *Torricelli Contra Mundum*, p. 48, H. K. Lewis and Co., Ltd., London).

GASES (*Continued*)—

portional to the inverse square roots of their densities. Under enormous pressures, it is stated that gases can permeate metals and liquids become compressible. With respect to the kinetic theory of gases, F. L. Teed states that there is no experimental foundation for it. (See his essay, "Torricelli contra Mundum," p. 54 (H. K. Lewis and Co.).)

The absorption of gases by the employment of gels is referred to elsewhere. (See Colloid Chemistry, Silica (p. 807), and Ferric Hydroxide (p. 502).)

The poisonous character of industrial gases and fumes was the subject of a recent lecture by Sir Thomas Legge. (See Poisons.)

References: "A Continuous Gas Indicator" (*Ind. Chem.*, 1932, viii., 57); A Friction Flow-Meter for Small Rates of Flow of Gas, by J. H. Yoe (*J.S.C.I.*, 1925, **44,** 432 T); simple forms of gas-circulating apparatus by Pearson and Thomas (*J.C.S.*, 1925, cxxvii., 2450), and by Chattergi and Finch (*J.C.S.*, cxxvii., 2464); A Portable Apparatus for Analysis of Illuminating and Other Gases, by H. D. Murray (*J.C.S.*, 1925, p. 769); a simple apparatus for the analysis of small samples of gas by H. R. Ambler (*Analyst*, 1929, **54**, 517); A New Apparatus for Gas Analysis, by E. R. Smith (*Chem. and Ind.*, 1932, **51,** 184); "The Ignition of Gases by an Explosion Wave," by Campbell and Woodhead (*J.C.S.*, 1926, p. 3010). The use of nickel-chromium-molybdenum steel is recommended for the transport and storage of permanent gases. See Reports of the Committee on "Welded Containers" for compressed gases, 1929 and 1930 (H.M. Stationery Office); Road transport regulations concerning gases in cylinders (*C.T.J.*, 1931, **89,** 197); dangers arising from working, packing, storage, and transport of various gases, etc, by H. J. Phillips (*Ind. Chem.*, 1926, ii., 197); "Gas Calorimetry," by M. Barash (*Ibid.*, 1928, iv., 336); *Gaseous Combustion at High Pressures,* by Bone, Newitt, and Townend (Longmans and Co.); *Clouds and Smokes,* by W. E. Gibbs (J. and A. Churchill); *Sorption of Gases and Vapours by Solids,* by J. W. McBain (G. Routledge and Sons, 1932); and Greenwood's *Industrial Gases* (Baillière, Tindall and Cox); Flash-point, Gas Washing, Ignition, Kinetic Theory, and Molecules.

GASOLINE—Name used in respect of varieties of hydrocarbon mixtures used for carburetting gases, also as illuminants, solvents, cleansing agents, in paint-mixing, and making rubber cements. It is commonly understood that of any such mixture used as motor spirit, 90 per cent. of the hydrocarbons should boil below 190° C. (374° F.), and all of them below 225° C. (437° F.); further, that the liquid should have a density of less than 50° Bé. In addition to the straight distillates from crude petroleum ranging in density from 50° Bé. to 90° Bé., there is a cracked product obtained from the higher boiling petroleum at a temperature of about 700° F. It is stated that the manufacture of "cracked gasoline" now exceeds the production of the product yielded by the original distillation of petroleum, while the gases which constitute a by-product (consisting chiefly of unsaturated hydrocarbons of the

GASOLINE (*Continued*)—
ethylene series) are used in making secondary alcohols and other valuable industrial articles. There is also a very volatile gasoline obtained by condensing the gas from the oil-wells known as "Casing-head Gasoline," and a number of other varieties of substitutes, including mixtures of benzol, tetralin, and distillates from shale, coal, and peat. "Alcogas" is an American product consisting of about one-third benzol and toluol (mixture), one-third alcohol and ether, and one-third gasoline or other petroleum distillate. The subject of gum formation in cracked gasolines and the consequent deterioration of such spirits are the subjects of papers by Wagner and Hyman, Mardles and Moss, S. J. M. Auld, W. S. Norris, and F. B. Thole respectively (*B.C.A.*, 1930, B, 446 and 447). (See also Motor Spirit, Petrol, and Petroleum.)

GASOMETER—Apparatus or plant to contain and measure gas.

"**GASSING**" from chlorine in chemical works is not infrequent, and is generally caused by the workmen entering the chambers wherein lime has been chlorinated in the manufacture of bleaching-powder, before the gas has been exhausted, and at other times owing to accidental leakages. It is usual for the workmen to hold rags or a cloth wetted with water or dilute sodium carbonate in their mouths to prevent injury.

In the Great War, gassing attacks were made by means of chlorine cloud produced by the use of liquefied chlorine, and various other substances were used, including cyanogen chloride ($CNCl$) (a colourless, poisonous liquid, which boils at 13° C.), chlorinated picric acid and phosgene (carbonyl chloride) ($COCl_2$) (which liquefies below $+8°$ C., and yields a gas of very suffocating odour), xylyl bromide and benzyl bromide (with which "tear" shells were at first filled), and later, chloromethyl and trichloromethyl chloroformates—highly poisonous bodies.

The so-called "mustard gas"' (yperite) was produced by use of the oily, liquid, dichloroethyl sulphide $(CH_2Cl,CH_2)_2S$ (prepared from ethylene by the action of sulphur monochloride), which, although it does not produce any immediate effect on the eyes, brings about most severe inflammation and intractable blisters later, acute pneumonia, and other serious results, due to its hydrolysis within the eye, leading to the formation of hydrochloric acid in the live cells.

A number of other chemical compounds, including sulphur trioxide, were also employed.

Suitable chemical applications for neutralizing these various poisons were provided as far as possible, being used as respirators. The gas-mask chiefly used in the British Army was Harrison's small box respirator, the metal container of which was known as "Harrison's Tower." In a paper issued from the United States Bureau of Mines, the conclusion has been drawn that for general use by firemen and otherwise, a respirator consisting of a canister filled with activated charcoal and surrounded with an effective filter for particulate clouds will prove of most general utility. The so-called "Universal" gas-mask as

"GASSING" (*Continued*)—

developed in the U.S.A. Bureau of Mines at Pittsburg has a canister of granular absorbents, consisting of activated charcoal for removing organic vapours; a filter of cotton-wool to remove smokes, dusts, and mists; caustic soda fused on pumice-stone to neutralize acid gases; another cotton-wool filter; fused calcium chloride to remove moisture that would inhibit action of the next absorbent; a mixture of the oxides of manganese and copper ("hop-calite"), with, sometimes, silver and cobalt, that catalyses the oxidation of carbon monoxide to carbon dioxide; and, finally, silica gel for absorbing ammonia. The mask and harness weigh about 8½ lbs. Some improved American types are described in the *C.T.J.*, 1926, **78,** 290; and a variety of the "Universal" mask by T. Legge in his lecture (Inst. of Chem., February 21, 1930). See also "Mine Rescue Apparatus: the S.M.R.B. Gas-mask" (H.M. Stationery Office, 1930), and the description of a laboratory form by A. Ashworth (*C.T.J.*, 1924, **75,** 614).

Breathing appliances to obviate danger by inhalation of deleterious substances may be classified in respect of their employment in chemical works as follows: those designed to purify the air by removing the contaminating impurities by chemical interaction, absorption, or mechanical removal (filtration), and self-contained oxygen breathing sets to make good any deficiency of oxygen in the atmosphere.

A solution containing sodium sulphide and soap, used in the form of a fine spray, has been found very effective in purifying the air from certain toxic gases, including chloropicrin, chlorine, phosgene, methylchloroformates, acrolein, bromoacetone, cyanogen chloride, and benzyl iodide, bromide, and chloride. Poisonous gases have been used for extermination of obnoxious birds, rodents and insects; chlorine giving good results against "pocket gophers" and ground squirrels, while sulphur dioxide, hydrocyanic acid gas, and phosgene have proved useful against rats. (See "Note on Chemical Warfare," *Chem. and Ind.*, 1926, **45,** 897; "Chemical Disarmament," by H. Levinstein *J.S.C.I.*, 1930, **49,** 71 T); and K. B. Quinan on "Mustard Gas" (*Ind. Chem.*, 1931, vii., 474, and 1932, viii., 30 and 70).

GASTRIC JUICE excreted from the peptic glands contains in 1,000 parts about 992 to 993 parts of water, 5 per cent. of various saline substances (particularly sodium chloride), 3 per cent. of pepsin, and a small quantity of free acids, including hydrochloric acid. It has the power of so altering the character of albuminous substances taken as food as to produce assimilable peptones, the product of stomachic digestion being chyme.

GAULTHERIA OIL (Oil of Wintergreen)—A colourless or slightly red essential oil of sp. gr. 1·175 to 1·193, ref. ind. 1·535, and b.p. about 218° C., obtained from the *Gaultheria procumbens*, or Canada tea, of the order Ericaceæ, which grows freely in N. America and particularly in New Jersey. It can be obtained from all parts of the plant, has a pleasant odour, and consists mainly (99 per cent.) of methyl salicylate, from which salicylic acid ($C_7H_6O_3$) can be prepared. It is stated to be derived from a glucoside by the action of an enzyme; is soluble in

GAULTHERIA OIL (*Continued*)—
alcohol, ether, chloroform, and carbon disulphide; and used in perfumery, confectionery, and for flavouring, also in medicine for rheumatic troubles, etc. (See Methyl Salicylate.)

GAY-LUSSAC TOWER—See Gas Washing and Sulphur (Sulphuric Acid).

GEDDA (**GHEDDA**)—See Waxes.

GEISSLER'S TUBE—A glass tube filled with a gas under low tension and provided with platinum electrodes, the gas being rendered luminous when an electric current is passed through.

GELATIN—An albuminous substance forming an important constituent of many animal tissues, including cartilages, bones, and horn. Commercially, it may be prepared from bones by digesting them in water acidified with hydrochloric acid, which assists in the separation of the gelatinous parts from the calcareous parts. In common with glue it is prepared from this glutinous product in the "pearl" form (referred to under the head of Glues) as well as in slabs and sheets. In the dry state it is almost colourless or has a slightly yellowish tint. It swells when placed in water, and becomes translucent, but does not dissolve to any great extent, although it passes into solution upon heating. According to the Food Investigation Board Report for 1927 (H.M. Stationery Office), gelatins from mammal or fish skins are better emulsifying agents than those extracted from bones of mammals or fish swim bladders. It has been shown that when a gelatin jelly is in equilibrium with water or dilute acid or alkali, it exists in the solution in the liquid surrounding the gel, and with the exception of the minimum "solubility" in the case of acids, gelatin dissolves to a greater extent in dilute acid or alkali than in water (Fairbrother and Swan).

The molecular structure of gelatins as prepared from various sources is not uniform and they differ slightly in composition, but contain approximately 50 per cent. of carbon, 6·5 to 7 per cent. hydrogen, and from 17·5 to 18 per cent. nitrogen. The molecular weight when purified and as determined from osmotic pressure measurements is about 40,000, commercial varieties giving about 30,000. (See Northrop and Kimopz, *B.C.A.*, 1926, A, 1098.)

By the electro-osmose process, using suitable diaphragms, it has been found possible to produce very pure gelatins from low-grade material, and even glue—so pure, in fact, that a 5 per cent. solution can be kept for months without bacterial growth, due to the absence of other food material which is essential to bacterial growth.

Gelatin is largely employed as a clarifying agent, also in the preparation of jellies, foodstuffs, confectionery, adhesives, medicinal capsules, and, among other purposes, for the preparation of a special class of paper by first impregnating it with a solution of gelatin and then hardening it in a bath of formaldehyde. Other papers of gelatinous nature are known as "Algophane," "Onion," and "Glassiene."

The food value of gelatin in terms of calories is stated to be about 1,570 per pound.

GELATIN (*Continued*)—

When liquefied by chloral hydrate, gelatine is stated to be well adapted as a glue for household purposes. A solution of even 1 per cent. gelatinizes on cooling. When dried, it is insoluble in alcohol or ether.

Notes on the testing of gelatin for jelly strength are given by Sheppard and Sweet (*Ind. Eng. Chem.*, 1921, **13,** 423); Lockwood and Hayes (*J.S.C.I.*, 1931, **50,** 145 T); *Chem. and Ind.*, 1931, **50,** 536; E. J. Gould (*J.S.C.I.*, 1930, **49,** 453 T); A. F. Tracey (*Chem. and Ind.*, 1931, **50,** 499); and Fellers and Clague (*Ind. Eng. Chem.* (*Anal.*), 1932, **4,** 106). (See also Satya Prakash on "Theory of Jelly Formation" (*J.S.C.I.*, 1931, **50,** 387 T); E. W. J. Mardles on "Dissolution of Gelatin in Liquids" (*B.C.A.*, 1932, A, 19); J. Knaggs on "Deaminised Gelatins" (*J.S.C.I.*, 1932, **51,** 61 T); F. L. De Beukelaer (*J.S.C.I.*, 1932, **51,** 94 T); N. L. Wright (*Ind. Chem.*, 1927, iii., 51); Agar, Chondrine, Glue, Isinglass, Proteins, and Size.)

GELOSE—See Agar-agar, Algin, and Seaweeds.

GELS—See Colloid Chemistry and Gelatin.

GELSEMININE (**Gelsemine**) ($C_{22}H_{26}N_2O_3$)—A yellowish-white, crystalline alkaloid, of m.p. 160° C., soluble in alcohol and ether. It has mydriatic properties and is extracted from the dried rhizome and roots of the yellow jasmine (*Gelsemium nitidum*, etc., N.O. Loganiaceæ). (See Chen (with others), *B.C.A.*, 1931, A, 871.)

GEMS—Precious stones, such as the diamond, ruby, topaz, and emerald. Imitations consist of coloured glasses, but the ruby and the sapphire, identical in all respects with the natural gems, are now produced commercially by the fusion of pure alumina. (See Aluminium.) The colour of the ruby and probably that of the sapphire is due to a small content of chromium; the emerald and aquamarine owe their green tint to the presence of ferrous iron, and are varieties of beryls; the amethyst and the garnet owe their colours to ferric iron or manganese, or both.

"GENOXIDE"—A brand of hydrogen dioxide.

GENTIAN is the dried root of the *Gentiana lutea* (a genus of Gentianaceæ), which grows abundantly in Switzerland, the Tyrol, and the Auvergne, and contains the sugar known as gentiobiase ($C_{18}H_{32}O_{16}$). An aqueous infusion is used as a bitter tonic in medicine and veterinary practice. The root contains several glucosides, including gentiopicrin, $C_{16}H_{20}O_9$, $\frac{1}{2}H_2O$, of m.p. 122° C. (which hydrolyses to dextrose and gentiogenin), and gentiin, $C_{25}H_{28}O_{14}$ (m.p. 274° C.), which crystallizes in yellow needles, etc; also a yellow colouring matter named gentisin ($C_{14}H_{10}O_5$). It is used in Germany and Switzerland in making an alcoholic drink. (See J. Shinoda (*J.C.S.*, 1927, p. 1983), and Almond Oil.)

GERANIAL—See Citral.

GERANIOL ($C_{10}H_{18}O$ or $C_9H_{15}CH_2OH$), the alcohol corresponding with citral, is a liquid constituent of a number of essential oils, and is the chief constituent (90 per cent.) of Indian geranium oil, which is used as a substitute for otto of roses. It is possibly the precursor of piperitol

GERANIOL (*Continued*)—
and piperitone; boils at about 228° C., has a sp. gr. of 0·8812, ref. ind. about 1·462, and is stereoisomeric with nerol. It is soluble in alcohol and ether, and by oxidation yields citral. (See Citral and Nerol.)

GERANIUM OIL (**Rose**)—Distilled from the herbs *Pelargonium radula, P. capitatum,* and *P. odoratissimum* in Algeria and other parts of Africa; is of pale yellow or greenish colour, having geraniol as its chief constituent, associated with some esters. There are a number of varieties used in perfumery, all being soluble in alcohol and ether, with a sp. gr. of 0·886 to 0·898 at 15° C., and rotation of $-7°$ to $-12°$ at 20° C. The yield is about 0·1 to 0·15 per cent. (See Geraniol.)

The **Turkish Oil** (**Palmarosa Oil**), which comes really from the East Indies, has a sp. gr. of 0·885 to 0·895 at 15° C., opt. rot. $-2°$ to $+2°$ at 20° C., and ref. ind. 1·474 to 1·485 at 20° C. It is distilled from the *motiya* variety of the native Rosha grass—a species of *Andropogon* (*Cymbopogon Martini*)—and contains some 70 per cent. geraniol; the yield is 1 per cent.; it is very similar to the "rose" oil, and used for the same purposes. (See Ginger-Grass Oil.)

Bourbon geranium oil from *Andropogon schœnanthus* comes from the Island of Réunion (Bourbon). The composition of Caucasian geranium oil differs very much from that of the Turkish oil, according to Rutovski (and another) (*B.C.A.*, 1930, B, 1131).

Japanese oils, obtained respectively from *Pelargonium graveolens, P. radula,* and *P. denticulatum,* grown near Tokyo, are reported to have sp. grs. 0·9178, 0·9234, and 0·8860, and total geraniol content as follows: 23·1 per cent., 26·3 per cent., and 63·5 per cent. respectively, the *P. denticulatum* variety being, therefore, the most valuable for perfumery.

"GERMANIN"—See "Bayer 205."

GERMANITE—A South-West African mineral reported to be richer in germanium and gallium (associated with other metals) than any other known mineral. W. F. de Jong gives it the formula $Cu_3(Fe,Ge)S_4$ (*B.C.A.*, 1930, A, 1352).

GERMANIUM (Ge) **and its Compounds**—Atomic weight, 72·6; sp. gr., 5·47; m.p., about 958° C. A rare element (found in the minerals *argyrodite, canfieldite,* and *germanite*), of which little is known, and described as both metallic and non-metallic—that is, on the borderland. It can be extracted from crude zinc oxide and other sources by methods based upon the volatility of germanium tetrachloride, which is obtained by passing chlorine over a strongly heated mixture of the dioxide and carbon. It is of crystalline character; is credited with a number of isotopes, of which numbers 72 and 73 are said to be peculiar (Aston), and combines with the alkaline hydroxides, forming compounds corresponding to silicates. There are two oxides, (GeO) and GeO_2, the latter being appreciably soluble in water, acids, and alkalies, a chloride ($GeCl_2$), tetrachloride, two sulphides (GeS) and GeS_2, and several hydrides. Germanium salts are said to be of value for the treatment of

GERMANIUM (*Continued*)—
certain forms of anæmia. Some particulars respecting germanium compounds are given by Dede and Russ (*B.C.A.*, 1929, A, 158); Schwarz and Schenk (*B.C.A.*, 1930, A, 4377); Dennis and Hulse (*B.C.A.*, 1930, A, 1387); W. Pugh (*J.C.S.*, 1929, pp. 1537 and 1994); *Ibid.*, 1930, p. 2369); W. Pugh on an improved method for extracting germanium from germanite (*J.C.S.*, 1929, p. 2540); and Patnode and Work (*Ind. Eng. Chem.*, 1931, **23,** 204).

GERMAN SILVER—See Alloys.

GERMICIDES—Preparations that kill bacteria and other germs. Many antiseptics, disinfectants, dyes, and oxidizing agents act efficiently as germicides, and these chemical substances can be employed according to their respective other properties and the nature of the applications to be made. (See Antiseptics, Bacteria, and Disinfectants.)

GERMS—See Antiseptics, Bacteria, and Disinfectants.

GHATTI GUM—See Gums and Resins, p. 425.

GHEDDA (East Indian Wax)—See Waxes.

GHEE—An Indian clarified butter made from buffalo milk, with or without added cow's, goat's or sheep's milk, from which moisture, casein, and other constituents have been removed. Its m.p. varies from 34° to 37·3° C., sap. v., from 227 to 238, and Reichert-Wollny value of buffalo ghee from 26 to 41·2 and that of cow ghee from 15·5 to 35·4. It is prepared in Somaliland and India, and is used both in cooking and as a food. For use as a food it is allowed to become rancid, then boiled until all the water is expelled, after which a little dhye and salt or betel-leaf is added, then potted for use as required. An imitation "Vegetable Ghee" is now made from hydrogenated oils suitably flavoured. (See Godbole and Sadgopal on its nutritive value, etc. (Benares: Benares Hindu Univ., 1930); and Bhattacharya and Hilditch on "The Fatty Acids and Component Glycerides of Indian Ghee" (*Analyst*, 1931, **56,** 161).)

GILSONITE (Mineral Rubber)—Utah and Texas deposits of very brittle asphalt of sp. gr. 1·065 to 1·070, soluble in carbon disulphide and hot turpentine; used for making varnishes, waterproofing, lining tanks, and as an insulating material. (See *C.T.J.*, 1927, **81,** 38; article by H. M. Langton (*Ind. Chem.*, 1929, v., 324 and 383); and Asphalt.)

GIN is spirit distilled from fermented wort of malted barley, and flavoured with juniper berries by distillation or otherwise.

"GINAL"—A preparation containing sodium alginate used in purification of beet and cane sugar. (See Algin.)

GINGER is the root of *Zingiber officinale,* a genus of Zingiberaceæ, which grows in India and China, and is largely cultivated in other tropical places. It contains a number of chemical substances, including up to 3 per cent. of a volatile oil, "gineroll." As to its pungent principles, see Nomura and Iwamoto (*B.C.A.*, 1928, A, 1375).

GINGER-GRASS OIL is distilled from the grass of a species of *Andropogon* (the *sofia* variety of native Rosha grass). It somewhat resembles

GINGER-GRASS OIL (*Continued*)—
geranium oil in character, and is used in perfumery. It contains 35 to 70 per cent. geraniol, has a sp. gr. about 0·91 at 15° C., opt. rot. +30° to +54° at 20° C., ester value 10·4, and ref. ind. 1·478 to 1·489 at 20° C. There are, however, a number of varieties from other sources including one obtained from *Cymbopogon Martini*. (See Geranium Oil and Naal Oil.)

GINGER OIL—Obtained (from 0·25 to 3 per cent.) by distillation from the dried rhizome of *Zingiber officinale,* is a yellowish, aromatic oil of burning taste, soluble in alcohol and ether, of sp. gr. about 0·88 at 15° C., opt. rot. −25° to −45° at 20° C., ref. ind 1·488 to 1·495 at 20° C.; is used in perfumery, for flavouring purposes, preparation of liqueurs, and as an aromatic addition to griping medicines.

The plant is cultivated in the West Indies, West Africa, India, China, and Japan, but the best ginger comes from Jamaica. It contains phellandrene and other bodies, including a sesqui-terpene named zingiberene, an alcohol named zingiberol ($C_{15}H_{26}O$) and zingerone ($C_{11}H_{14}O_3$). Respecting the pungent principles of ginger, see Nomura (with others) (*B.C.A.*, 1930, A, 617).

GINSENG—The root of *Panax quinquefolium* (order Araliaceæ), containing a saponin, volatile oil, fatty oil, and glucoside. It finds technical uses, and is employed medicinally by the Chinese.

Korean and Canton ginsengs are of approximately equal qualities.

GLASS—Glasses have been defined by C.H. Desch as "undercooled liquids of high viscosity," and thus distinct from ordinary solids and crystals. They are fused mixtures of silicates of potassium or sodium with one or more other silicates which are insoluble in water, such as silicate of calcium, magnesium, etc., the silicates of the alkalies alone being soluble in water. Mediæval window-glass was a potassium-calcium silicate, the alkali being obtained from the ashes of plants, whereas the modern glass is of a soda-lime character. In practice, ground quartz or flint or clean sand (free from iron), mixed with potassium or sodium carbonate and the other ingredients, are fritted together in ovens or furnaces of various designs, by which means the silica of the quartz or sand enters into combination with the bases, thus forming glass.

Fire-clay pot furnaces are gradually being superseded by so-called tank furnaces, not only in respect of sheet glass, but for green and blue signal lights, selenium ruby glass, electric light bulbs, etc.

The "cyclone tank" is a newer kind of furnace, by means of which British glass can be made much more cheaply than heretofore.

It is of importance that the sand should be of high purity (98 to 100 per cent. SiO_2) and free from iron oxides, alumina, magnesia, lime, and alkalies, or nearly so. When the iron content is not more than 0·20 per cent. in the sand, the green colour of the glass can be neutralized by some decolourizer, such as manganese, selenium, cobalt, or nickel.

Common glass is stated to have a composition approximately represented by the formula $Na_2O,CaO,6SiO_2$.

There are many and very great varieties of glass, differing from each

GLASS (*Continued*)—

other in their respective compositions, qualities, and uses. When the mixture used (as for plate-glass making) consists only of sodium carbonate, calcium carbonate, and sand, the two carbonates are first of all fused together, and then at a higher temperature they are decomposed by the silica (of the sand), the two bases combining therewith, whilst carbon dioxide is evolved. The greater the silica content, the higher is the resistance to heat. The changes occurring at different temperatures during the fusion of mixtures yielding three typical glasses (soda, lead, and sulphate glasses) have been studied by Tammann and Oelsen (*B.C.A.*, 1930, A, 1511).

Cullet (refuse glass) is largely used in making up glass batches in amounts varying with the types of glass and the method of working, and from experimental work conducted by various research workers, it would appear that, subject to certain conditions, including the maintenance of the chemical composition of the glass by observing the proper heating, the addition of cullet is unobjectionable.

Window or **Soda-Lime Glass** is made by fusion from a mixture of sand, sodium carbonate or sodium sulphate, and lime or limestone of clear good quality, and has a low fusion-point. The usual soda-lime-silica glasses may be regarded as ternary mixtures of Na_2SiO_3, $CaSiO_3$, and SiO_2, the two crystalline silicates being held in solid solution by the excess of silica present in the glass. (See E. P. Arthur (*B.C.A.*, 1926, B, 488).) Some typical analyses show SiO_2, 71·9 to 74·3 per cent.; $CaO + MgO$, 11·1 to 14·2 per cent.; Na_2O, 12·7 to 15·1 per cent.

Recently varieties of glass have been produced which transmit light of wave-length less than 3200 Å, to which ordinary window glass is practically opaque (*Chemiker Zeitung*, April 4, 1928), and these new varieties are likely to come into use in hospitals, etc.

Bohemian Glass is made in considerable quantities at Sazava and elsewhere from pure potassium carbonate and powdered quartz, and is not so fusible as window-glass, one type capable of resisting chemical action having the composition: SiO_2, 77 per cent.; K_2O, 7·7 per cent.; CaO, 10·3 per cent.; and Na_2O, 5 per cent.

Flint and **Lead Glass,** containing about 38 to 50 per cent. lead oxide, is made from ground flint, lead oxide, and potassium carbonate, with or without some added nitre, and is very fusible, the ordinary household glass articles being made from this quality.

Plate Glass is rolled whilst soft into sheets and has a composition approximating to silica 72 per cent., alumina 1·1 per cent., lime 14·3 per cent., and soda 12·4 per cent.

Bottle Glass of green colour is made of silicates of sodium, calcium, and aluminium, the colouring being supplied by oxide of iron. To impart other colours, other metallic oxides are used, that of manganese giving a purple tint, cobalt oxide a blue colour, copper oxide a ruby red; glasses free from heavy metals are coloured yellow by sulphur; to strongly alkaline glasses selenium gives a chestnut-brown

GLASS (*Continued*)—

colour; tellurium can be used to give a purple-red and in some other cases a blue coloration; chromium oxide gives greens or reds; and so on.

Arsenious oxide is used in making many qualities of glass, amongst other purposes, to correct the green tint which traces of iron would otherwise give to it, by oxidizing it from a ferrous into a ferric state.

According to Turner, the mixture used nowadays ranges between the following limits: sand (iron-oxide $<0{\cdot}06$ per cent.) 1,000 lbs., soda-ash 330 lbs. to 380 lbs., pure limestone 180 lbs. to 230 lbs., arsenious oxide $1\frac{1}{2}$ lbs. to $2\frac{1}{2}$ lbs., selenium $\frac{2}{5}$ oz. to $\frac{4}{5}$ oz., cobalt oxide $\frac{1}{12}$ oz. to $\frac{1}{16}$ oz. (See *J.S.C.I.*, 1929, **48,** 65 T.)

Selenium is used as a decolorizing agent. (See Selenium.)

Zirconia can be used to some extent to replace silica in glass-making. (See Zirconium.) With respect to the employment of titania in glass-making, see Titanium.

Crystal Glass for table and artistic ware is stated by Turner, in his paper already referred to above, as made from sand (iron oxide $<0{\cdot}02$ per cent) 1,000 lbs., red-lead oxide 660 lbs., potash (K_2CO_3) 330 lbs., potassium nitrate 50 lbs., manganese dioxide 1 lb. to $1\frac{1}{2}$ lbs., and arsenious oxide 1 lb. to $1\frac{1}{2}$ lbs.

Some published analyses of different varieties of glass are as below:

	Plate.	Window.	Lime Flint.	Lead Flint.	Bohemian.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
SiO_2	71	71	74	54	71
CaO	13	11	—	—	10
PbO	—	—	—	35	—
Na_2O	14	15	19	—	2·5
K_2O	—	—	—	11	12·5
Al_2O_3 and Fe_2O_3	1 to 2	1 to 2	—	—	9

For chemical apparatus, a soda-lime glass is preferred for the most part, although the potash-lime glass is superior when the articles to be made should be hard or difficult to fuse, as, for instance, glass combustion tubing used in making organic analyses.

Up to the time of the Great War, Thuringia and Bohemia enjoyed almost a monopoly of this chemical glass industry; but as a result of investigations conducted by British chemists during the war, working formulæ or recipes for a number of qualities for chemical and other scientific purposes were successfully introduced to manufacturers in this country. One of the best of these is a zinc-aluminium-borosilicate quality. The analysis of a Jena glass beaker gave the following composition: SiO_2, 64·66 per cent.; Al_2O_3, 6·74 per cent.; ZnO, 10·12 per cent.; CaO, 0·08 per cent.; MgO, 0·13 per cent.; Na_2O, 7·21 per cent.; B_2O_3, 11·14 per cent.; Fe_2O_3, 0·10 per cent.; the salient components being the Al_2O_3, ZnO, B_2O_3, the silica, and the alkali.

Water exercises a corroding effect on glass, some kinds of which, when boiled in water, actually gain in weight.

GLASS (*Continued*)—

The tests of good glasses for chemical use include the action of boiling water, boiling water under pressure (autoclave), and the action of salts, acids, and alkalies. The power to withstand sudden changes of temperature is an essential property for chemical glass. (See "Chemical Glassware," by H. D. Renn (*Ind. Chem.*, 1926, ii., 270 and 361), and W. Singleton (*Ibid.*, 304).)

A test that has proved satisfactory is to heat a solution of 1 part in 1,000 of the alkaloid narcotine hydrochloride in the vessel to boiling-point, and if the glass is of poor quality, the alkaloid is thrown down as a fine precipitate. If this occurs after ten minutes, the glass is to be condemned, and if within twenty minutes, the glass is poor, good glasses not showing any deposit for an hour.

A new device in glass apparatus in the nature of a tight non-rigid joint for glass and silica ware on the "ball and socket" principle originated by Max Haas is described by E. I. Lewis (*Chem. and Ind.*, 1928, **47,** 1238).

"Pyrex" is a variety of laboratory glass highly resistant to water and acids, but not so resistant to alkalies, used also for baking ware, and as a competitive with chemical stoneware. It has a smaller co-efficient of expansion (0·0000032) than either porcelain or ordinary glass, so that beakers and flasks can be made with thicker walls than usual, thus increasing their durability. The softening-point is about 800° C., although it softens slightly under pressure at above 600° C., and is not affected with devitrification in its working range. It contains about 80 per cent. silica and 12 per cent. boric oxide (B_2O_3), 4 to 5 per cent. alkaline oxides, and about 2 per cent. alumina, the durability of the glass being at its maximum with this content of the boric oxide. It does not absorb heat by solar radiation to the same extent as porcelain, and has ideal properties for electric insulation.

"Monax" is a borosilicate glass of high resistance, which softens at about 720° C., with a co-efficient of expansion of 0·0000044, and can be quenched in cold water from 240° C. without breaking. "Chance's resistance glass" is another variety.

Fused Silica or **Quartz Glass** of opaque and transparent characters is now largely used in the construction of chemical apparatus and plant, as it only melts at about the same temperature as platinum, and is very resistant to the action of chemicals. Moreover, it is not liable to breakage by sudden changes of temperature. (See Burrows Moore on "Fused Silica in Industry" (*Chem. and Ind.*, 1931, **50,** 671), and Silicon.)

"Vitreosil"—A trade proprietary name for pure fused silica (99·8 per cent. SiO_2) used for making laboratory ware of great strength and durability, heat and acid proof; made in opaque, translucent, and transparent varieties, sp. gr. about 2·7; having the low-expansion co-efficient of 0·00000054 and m.p. between 1,700° and 1,800° C.

It is said that "Vitreosil" plants can be shut down and restarted without damage. (A "Vitreosil" air lift pump is described by B. Moore (*Ind. Chem.*, 1931, vii., 201), and a "Vitreosil" gas ejector pump (*Ibid.*, 282).)

GLASS (*Continued*)—

(See Porcelain, and for detailed information concerning "Clear Fused Quartz," see E. R. Berry (*C.T.J.*, 1924, **74**, 707).)

Safety (Laminated) Glass—Varieties of this character, designed to decrease splintering under impact, depend upon the employment of a tough material between two hard and relatively brittle sheets—using, for example, such substances as cellulose acetate, celluloid, or gelatin, protected by an enamel or varnish. (See W. R. Lyttleton (*Chem. and Ind.*, 1929, **48**, 92); "Some Notes on Safety Glass Manufacture" (*Ind. Chem.*, 1930, vi., 107 and 467); *Ibid.*, 1931, vii., 490 and 501; some "Notes on Testing Safety Glass," by Murray and Spencer (*Ibid.*, 1930, vi., 399); and "Problems of Safety Glass Manufacture," by T. Pesch (*B.C.A.*, 1931, B, 1049).)

With respect to ultra-violet light-transmitting glasses, Starkie and Turner (*B.C.A.*, 1929, B, 245) have determined some as follows: "Sanalux" 73 per cent., "Sun Ray" 62 per cent.; "Holvi" 61 per cent., "Vita" 54 per cent., "Helio" 52 per cent., "Uviol" 46 per cent., while "Corex," having the lowest iron oxide content, transmitted practically as much light as quartz (89 per cent.), although the other glasses were more durable upon exposure.

"Actinic" Glass—Crookes used cerium salts, also biotite, as ingredients to produce glass which would prevent the passage of heat rays and certain deleterious light rays, in order to protect the eyes of labourers engaged in glass-works. This so-called "actinic glass" is now made commercially in forms of "plate," "wire," "aqueduct," "corrugated wire," etc., the "aqueduct" quality being used for roofing, skylights, etc. The following composition of a batch for such glasses is published: Sand 1,300 pounds, soda ash 400 pounds, borax 20 pounds, lime 200 pounds, nitre 40 pounds, manganese oleoxide 85 grms, titanium oxide 30 grms., nickel oxide 35 grms., artificial biotite 40 pounds; whilst that of the artificial biotite is given as consisting of micaceous hæmatite 40 pounds, precipitated alumina 5 pounds, solid sodium silicate 50 pounds, magnesite 5 pounds, manganese dioxide 30 grms., all finely ground and thoroughly mixed before addition to the batch, the whole being fused together at 1,100° C.

Opacification of glass results from the colloidal separation of materials added for the purpose, aluminium compounds being often used in association with fluorides and fluorosilicates. Barium carbonate, cryolite, sodium-silico-fluoride, and sodium fluoride are approximately equally effective as opalizers, while sulphates, chlorides, phosphates, and tin oxide are also used. Zirconium is used in the production of clouded opal glass, while neodymium and praseodymium are also employed in making certain other special glasses, and on account of their allochroism for making artificial gems. (See *C.T.J.*, 1929, **85**, 426). On account of the physical and tinting characters imparted to glass, the use of the rarer metals is rapidly increasing. (See *C.T.J.*, 1930, **87**, 324.)

The beneficial influence of manganese oxide by replacing soda to

GLASS (*Continued*)—
some extent in glass batches in certain cases has been demonstrated by Turner and some associates. (See *C.T.J.*, 1930, **86**, 139.)

Devitrification—that is, loss of opacity or vitreous character by crystallization—is most commonly due to separation of silica, and occurs more readily in glasses containing lead oxide than in those containing the same proportion of calcium oxide. The tendency to devitrification of glass, favouring fracture, is sometimes regarded as a surface phenomenon connected with the affinity of glass for water and carbon dioxide. With sheet (window) glass the danger temperature region is from 700° to 800° C., and the addition of alumina raises the degree 5 per cent., causing a rise of about 100° C.

Preparations used for polishing glass include rouge (ferric oxide), "glassite" (containing the black oxide of iron as its principal constituent), fine carborundum (silicon carbide) after treatment with hydrofluoric acid and using oil as a medium, and carbon prepared in a suitable physical condition for use as an abrasive. (See also Enamels.)

Other references: An apparatus for measuring the softening temperatures of glasses (*Ind. Chem.*, 1927, iii., 232); article on "Glass Technology," by W. E. Turner (*Ind. Chem.*, 1925, i., 32); J. B. Murgatroyd (*Chem. and Ind.*, 1930, **49**, 34); Turner and Winks on "The Thermal Expansion of Glasses of Three or More Constituents" (*Chem. and Ind.*, 1930, **49**, 219); F. W. Preston on "Chemical and Physico-Chemical Reactions in the Grinding and Polishing of Glass" (*B.C.A.*, 1930, B, 988); H. V. Renn on "Semi-Opaque Glasses" (*Ind. Chem.*, 1925, i., 383); W. M. Hampton on "Coloured Glasses" (*J.S.C.I.*, 1928, **47**, 192 T); "Glass Colouring Agents" (*C.T.J.*, 1927, **81**, 103); *Chem. and Ind.*, 1927, **46**, 234); A. E. Marshall on "Applications of Glass to the Chemical and Allied Industries" (*J.S.C.I.*, 1928, **47**, 243 T); W. E. Turner on the "Physical Properties of Glasses and their Relationship to Chemical Composition and Mode of Preparation" (*J.C.S.*, 1926, p. 2091); P. Haller on "Slip Cast Tank Blocks" (*Chem. and Ind.*, 1931, **50**, 393); Partridge and Adams on "Clay Mixtures for Glass Melting Pots" (*Ibid.*); *A Bibliography of Glass*, by G. S. Duncan (H. F. and G. Witherby, High Holborn, London); *Notes on the Analysis of Glasses, etc.*, by W. E. Turner (Society of Glass Technology, Sheffield); *A Textbook of Glass Technology*, by F. W. Hodkin and A. Oousen (Constable and Co.); a series of papers on the "Constitution of Glass," edited by W. E. Turner (Society of Glass Technology); *Defects in Glass*, by C. J. Peddle (Glass Publications Ltd.); *Volumetric Glassware*, by V. Stott (Witherby); and *Glass Research*, x., 1927 (Department of Glass Technology, University of Sheffield).

GLASS-BLOWING is an art that can only be acquired by practice. Suppose it is desired to make a sealed tube with a bulb at one end: a piece of glass tube of the desired size and length—say $\frac{1}{8}$ inch diameter and 4 or 5 inches long—is taken, and one end placed in a Bunsen or blow-pipe flame until the glass softens sufficiently to mass together, and become solid to the extent of about $\frac{1}{8}$ inch; the mouth should then be applied to the open end, turning the tube round in the fingers mean-

GLASS-BLOWING (*Continued*)—
while and blowing with enough pressure to swell out the molten glass until a bulb of the right size and shape is obtained.

Bulb-tubes thus prepared are useful for observing the behaviour of solid chemical substances placed in them for that purpose when heat is applied. The conveyance to the bulb-tube of the substance to be examined can be easily effected by the use of a sharply channelled slip of paper. Used in this way iodine will be seen to volatilize, give off fumes of its own colour, and to recondense to the solid state in the upper (cooler) part of the tube; sulphur can be seen to melt and pass through the stages described under that heading, including sublimation and recondensation; mercury can be sublimed and seen to condense on the upper cool part of the tube; so also ammonium chloride; lead filings can be melted in the bulb, while white lead is decomposed, carbon dioxide being given off as gas, and yellow litharge being left behind.

Glass **T**-pieces can be made with a little practice, and are often wanted in the laboratory. Take a piece of glass tube of the desired length, and plug one end with a small boring of cork; then hold it in the flame of a blow-pipe so that a fine tongue of flame impinges upon and heats the tube in one spot only, near the middle; and when it is observed to be red-hot, remove the tube from the flame and place the open end quickly in the mouth. Upon blowing, the molten part will become distended into balloon form, so thin that it can easily be broken, thus leaving a hole in the tube the edges of which can be rounded off with a file. Next, take another piece of glass tube and blow a bulb at one end as previously described, taking care, however, in this case, to blow the bulb as large, and therefore as thin, as possible. This bulb is then to be broken and the edges rounded off as in the other case with a file, when it remains to join the two pieces together. We have then the one tube with a hole in its side, and the other with one end provided with a sort of lip or flange roughly fitting the hole as to size. The flame of the blow-pipe should now be applied to both these parts as held together, and when sufficiently softened by heat they can be joined (welded) in the flame.

GLASS (LABORATORY) MARKING—Various methods of marking laboratory glass and other articles are described by A. W. Knapp (*J.S.C.I.*, 1929, **48,** 126 T), one ink recommended for glass being a coloured solution of shellac. Morkert and Hatfield use a 30 per cent. aq. Na_2SiO_3 solution and a steel pen (*Ind. Eng. Chem.*, (*Anal.*), 1931, **3,** 242.)

GLASS SUBSTITUTE, of unbreakable character, is the so-called urea-formaldehyde glass; a transmitter of ultra-violet radiation.

GLASS TUBES are of various diameters, the ordinary size being about 5 millimetres outside diameter. They can be bent to any desired shape by heating (meanwhile turning them round), until softened in the flame of a fish-tail gas burner, and then applying pressure at the two ends by the hands until the desired bend or angle is reached. A glass tube can

GLASS-TUBES (*Continued*)—

be drawn out to a smaller dimension or to a fine point when heated, as, for example, when it is desired to make the longer pointed tube for use in a wash-bottle. When the tube so drawn out has cooled, it is cut at the drawn-out part. During this heating, the tube becomes covered with deposited soot (due to the imperfect combustion of the carbon constituents of the gas), and it is best to leave this on the glass until it is cold, as by so doing the cooling (annealing) is prolonged and there is consequently less liability to subsequent fracture.

To cut a glass tube, place flat on a bench, and then with the edge of a triangular file make a scratch where it is to be cut. Upon grasping the tube firmly in both hands and application of gentle pressure at the scratched part, it should break evenly across. When the tube is thick or the diameter greater, several file markings should be made in the same circumferential ring, or the filings should be made deeper. The rough edges of glass tubes can be ground off with a flat file or rounded off evenly by softening in the edge of a Bunsen flame. (See *Practical Glass Manipulation,* by D. B. Briggs (Crosby Lockwood and Son).)

GLAUBERITE—A crystalline native double sulphate of sodium and calcium ($Na_2Ca(SO_4)_2$), of crystal system, No. 5, and sp. gr. 2·7, occurring in New Castile, Arizona, New Mexico, Bavaria, at Vic (France), and at Tarapaca in Peru.

GLAUBER'S SALTS ($Na_2SO_4, 10H_2O$)—Crystal system No. 5, and sp gr. 1·48. (See Sodium (Sulphate).)

"GLAUCONITE"—A compound mineral silicate containing some potash, employed like "Permutit" for water-softening.

GLAZES—Fusible mixtures used in the ceramic industries. (See Enamels, Porcelain, and Refractories, and E. Schramm on "Sand-Blast Abrasion Test for Glazes" (*B.C.A.*, 1929, B, 519).

GLIADINS—Vegetable proteins soluble in alcohol, such as glutein of wheat and hordein of barley. (See Haugaard and Johnson, *B.C.A.*, 1930, A, 1459.)

"GLITTO"—A proprietary scouring powder, being a combination of soda-ash and silicate.

GLOBULINS—A class of proteins insoluble in water, but soluble in acids, alkalies, and a dilute solution of salt, including globulin from the crystalline lens of the eye, and fibrin of blood; coagulable by heat. (See Albumins and Proteins.)

"GLOCO"—Name of a reputed smokeless coal resulting from a process of low-temperature carbonization.

GLOVER'S TOWER—See Gas Washing and Sulphuric Acid.

GLUCINUM (Gl)—See Beryllium.

GLUCONIC ACID—See R. Schreyer on its production from sucrose by moulds (*B.C.A.*, 1931, A, 1457), and Glucose.

GLUCOSANES (Glucosans)—Polysaccharoses which, upon hydrolysis, yield hexoses. (See Glucose.)

GLUCOSE (**Dextrose**)—There are a number of sugar-like bodies termed glucoses, the best-known member being grape sugar, or dextrose ($C_6H_{12}O_6,H_2O$), which is crystalline, soluble in water, and melts at 86° C. Glucose and sugars of the hexose and pentose types are now supposed to be built up in the form of a six-atom ring which can be represented as a hexagon (Haworth). *d*-Glucose is contained in honey and in most sweet fruits, and can be prepared from sucrose (cane sugar) or starch by hydrolysis with dilute acids: $(C_6H_{10}O_5)_n + {}_nH_2O = {}_nC_6H_{12}O_6$.

Commercial glucose is chiefly made by the more or less prolonged action of dilute hydrochloric or sulphuric acid under pressure upon maize or other starch, and is stated to be a mixture of real glucose with varying proportions of dextrin and maltose. When sulphuric acid is used it is subsequently removed by chemical means and the syrup evaporated in vacuum pans until semi-solid, after which it can be run into moulds, constituting, when cold, a hard opaque substance, white or slightly yellow in colour.

There are three grades of the commercial product—viz., liquid, solid, and crystalline. The liquid form of sp. gr. about 1·430 containing 14 to 18 per cent. water is really the incompletely hydrolysed product of the same process that yields the other two forms; that is to say, the process is arrested at an earlier stage. The solid product is obtained by a continuation of the process until the dextrin content is reduced to 5 per cent. neutralisation of the liquor, then continued concentration to a sp. gr. of 1·5 and cooling in moulds. The crystalline variety (one form of which is known as "Ceralose") is much less sweet than sucrose (about 65 per cent.), and is prepared by the same general process, subject to certain modifications of treatment, details of which will be found in an article by A. E. Williams (*Ind. Chem.*, 1930, vi., 495).

The manufacture of commercial glucose (dextrose) is described in detail in *Starch: its Chemistry, Technology, and Uses,* by Eynon and Lane (Heffer and Sons, Cambridge).

In all three forms glucose is largely used by brewers and others in the manufacture of alcohol and various fermentative processes, also in making jams, confectionery, syrup, vinegar, wines, caramel, and in the paper, textile, and leather trades.

The solid variety sometimes contains up to 50 per cent. or more of inverted products (chiefly gentiobiose—a reducing disaccharose—which is not fermented by yeast) other than glucose.

Dry sawdust or cheap firewood treated with very strong hydrochloric acid results in the conversion of the cellulose content into sugars, mostly glucose (about 65 per cent.), but the operation necessitates the use of "Prodorite" or stoneware vessels. In Switzerland the acid is recovered by introducing hot oil into the resulting product, the acid being evaporated and condensed while the remaining mixture is separated into syrup and oil in a centrifugal machine. (See Sugar.)

At Los Angeles wood waste is subjected to a process ("Kocher's") of

GLUCOSE (*Continued*)—

treatment with hydrochloric acid gas under pressure, whereby glucose 80 per cent. fermentable is obtained, with the production of 65 to 70 gallons of ethyl alcohol per ton of sawdust. (See Alcohols, p. 22.)

When cane sugar is hydrolysed by acid treatment it is converted into so-called "invert sugar"—that is, a mixture of glucose with fructose, and it has been shown that these two substances and mannose—another variety of glucose derived from mannitol—are partially and mutually transformable. Inverted sugar is uncrystallizable.

When glucose is heated to 150° to 155° C. under reduced pressure, it loses water and is converted into the anhydride glucosan ($C_6H_{10}O_5$), which can be obtained in a deliquescent crystalline form, melting at 108° to 109° C., and, when heated with water, is retransformed into glucose. It has been shown by Irvine that when glucosan is fused with a trace of certain metallic chlorides it becomes opaque and passes into a white amorphous substance which analyses like starch. When heated to 198° C., glucose is converted into caramel. By oxidation with bromine water, glucose yields gluconic acid ($C_6H_{12}O_7$); this acid is also produced by the growth of the mould *Aspergillus niger* in nutrient sucrose solutions, and its use has been suggested to take the place of vegetable acids for many commercial purposes. Its manufacture by fermentation of dextrose solutions, using a strain of *Penicillium buteum purpurogenum,* has been successfully demonstrated.

By heating cotton cellulose in a distilling apparatus under the reduced pressure of 10 to 15 mm. it decomposes at 210° C., and an oil of composition represented by $C_6H_{10}O_5$, supposed to be the anhydride named lævo-glucosan, equal in weight to 45 per cent. of the cellulose distils over and subsequently solidifies. It has been proved that crystalline glucose (m.p. 145° F.) can be obtained from normal cotton cellulose to the extent of 90 per cent. of the theoretical amount. (See A. E. Williams on "The Manufacture of Glucose from the Manihot Root" (*Ind. Chem.*, 1931, vii., 375), and from potato starch (*C.T.J.*, 1932, **90,** 151 and 181); Carbohydrates, Dextrose, Gluconic Acid, Invertase, Levulose, Manioc, and Sugar.)

GLUCOSIDES—A class of organic compounds found present in many vegetable tissues, which are resolved by hydrolysis (as effected by the action of enzymes, acids, or alkalies) into a sugar (usually *d*-glucose) and other organic substances. Some give arabinose and others rhamnose, and they are classified according to the sugar produced from them by hydrolysis, those giving rhamnose, for instance, being termed rhamnosides, and so forth.

Amygdalin ($C_{20}H_{27}NO_{11}$) is a white, crystalline glucoside found present in the bitter almond, also in apricot and peach kernels; it has been synthesized, and it is decomposed in the presence of water by the action of an enzyme (emulsin) contained in the tissue of the almond as follows:

$$C_{20}H_{27}NO_{11} + 2H_2O = C_7H_6O \text{ (benzaldehyde)} + HCN \text{ (hydrocyanic acid)} + 2C_6H_{12}O_6 \text{ (glucose)}.$$

GLUCOSIDES (*Continued*)—

Æsculin ($C_{15}H_{16}O_9$)—Contained in the horse-chestnut bark. (See Head and Robertson (*J.C.S.*, 1930, p. 2434) and A. K. Macbeth (*Ibid.*, 1931, p. 1288).)

Arbutin ($C_{12}H_{16}O_7$), from the leaves of the pear-tree, the pear-berry, and the dried leaves of *Saxifraga crassifolia*, resolved by emulsin into tetramethyl glucose and hydroquinone. (See Hydroquinone.)

Capsularin ($C_{22}H_{36}O_8,H_2O$), previously named corchorin, from the seeds of *Corchorus capsularis*, which yields a substance of composition $C_{16}H_{26}O_3$ upon hydrolysis.

Castelin ($C_{15}H_{22}O_8,3H_2O$), from *Castela Nicholsoni* of the natural order Simarubaceæ, which yields castilagenin ($C_9H_{12}O_3$) upon hydrolysis, accompanied with a bitter principle named castelamarin.

Coniferin ($C_{16}H_{22}O_8,2H_2O$)—Contained in the cambium sap of various fir-trees (*Coniferæ*), and a source of vanillin. (See Vanilla.)

Cornin ($C_{19}H_{21}O_9,OMe$), from the root bark of *C. florida* L. (See *B.C.A.*, 1928, B, 1137.)

Datiscin, $C_{27}H_{30}O_{15},4H_2O$, which occurs to about 6 to 10 per cent. in the dry weight of the roots and leaves of *Datisca cannabina* L.

Delphinin—See Delphinin and Plant Colouring Matters.

Digitonin, Digitalin, and **Digoxin**—See Digitalis.

Frangulin (**Buckthorne**)—From *Rhamnus frangula* bark. Bridel and Charaux give it the composition $C_{21}H_{20}O_9,H_2O$ (*B.C.A.*, 1931, A, 131). (See also Persian Berries.)

Fraxin, from *Fraxinus excelsior*. (See Wesseley and Demmer, (*B.C.A.*, 1929, A, 298).)

Gentiopicrin, from *Gentian*. (See Gentian.)

Glycerol glucoside, obtained by saturating a glycerol solution of glucose with hydrogen chloride, is described as a hexamethyl glycerol glucoside.

Glycyrrhizin—See Liquorice Juice.

Hederin ($C_{42}H_{66}O_{11}$)—From ivy. (See Hederin.)

Hesperidin ($C_{22}H_{26}O_{12}$)—A constituent of unripe oranges, which yields glucose, etc., upon hydrolysis. (See F. E. King and A. Robertson, *J.C.S.*, 1931, p. 1704.)

Indican—From which indigo is made. (See Indigo.)

Melilotoside—From *Melilotus altissima*, etc. ($C_{15}H_{18}O_8,H_2O$), which yields coumaric acid and dextrose.

Ouabain—Content of strophanthus seed.

Pelargonin—See Plant Colouring Matters.

Phloridzin ($C_{21}H_{24}O_{10}$)—A constituent of the root bark of apple, pear, cherry, and plum trees. (See Phloridzin.)

GLUCOSIDES (*Continued*)—

Picrocrocin—Contained in saffron. (See Saffron.)

Populin—Contained in the aspen. (See Populin.)

Purapurine—An alkaloid-glucoside found in *Solanum aviculare*. (See A. A. Levi, *J.S.C.I.*, 1930, **49**, 395 T.)

Quercitrin—See Quercitrin and Rutin.

Rhamnicoside ($C_{26}H_{30}O_{15},4H_2O$)—Found in the bark of the stem of the purgative buckthorn—the source of China green.

Rubian—Contained in madder. (See Rubian and Madder.)

Rutin—Contained in rue. (See Rutin.)

Salicin ($C_{13}H_{18}O_7$)—Present in the bark of the willow and in poplar buds. (See Gaultheria Oil, Salicin, and Salicylic Acid.)

Saponins—See Saponins.

Scammony—See Gums and Resins, p. 427.

Sinigrin—Contained in black mustard seeds. (See Mustard.)

Solanine ($C_{54}H_{96}O_{18}N_2,H_2O$)—From *Solanum sodomacum*. (See Solanine.)

Strophanthin—See Strophanthus.

Syringin—The glucoside of syringa.

Tannin—See Tannins.

Most glucosides are hydrolysed by emulsin, but are usually accompanied in the plant tissues containing them by enzymes which are also capable of effecting their hydrolysis. (See "Syntheses of Glucosides," by A. Robertson (*J.C.S.*, 1927, p. 1937); W. J. Hickinbottom (*J.C.S.*, 1928, p. 3140); Robertson and Waters (*J.C.S.*, 1929, p. 2239; *Ibid.*, 1930, p. 2729, and *Ibid.*, 1931, pp. 72 and 1881); Jones and Robertson (*Ibid.*, 1930, p. 1699); Enzymes and Rhamnosides.)

GLUES—There are many brands, including so-called "size," all being hydrolytic derivatives of the nitrogenous tissue substances, mainly consisting of glutin associated with small amounts of chondrin and mucin. Ordinary glue is a degraded form of gelatin made from bones, the parings of hides, the pith of horns, and other animal offal, such as tannery waste, by boiling with water and pouring the liquid (after concentration) into frames or moulds, in which it sets to a solid mass. Fish glue is made from the bony structures of the heads of fishes, and is largely used for making adhesives, in finishing textiles, as an addition to certain rubber goods, and in the felt-hat trade, etc. A good variety of glue can now be prepared from chrome leather waste. (See Tanning.) A good glue should not attract moisture, and should be capable of absorbing six to seven times its own weight of water without liquefying. The final test of a glue is the tensile strength of a joint prepared from it.

Liquid glue is made by treating ordinary glue with acetic or hydrochloric acid, when it loses its gelatinizing property, but retains its adhesiveness. Glues can also be liquefied by the action of enzymes, but with some loss of adhesiveness. The properties desirable in liquid glue

GLUES (*Continued*)—
depend upon the intended use, but the gelatin and gelatose content should be high and the gelatin and amino-acid content should be low, high viscosity, low moisture, and neutrality being desirable features.

Glue is generally marketed in slab or sheet form by drying the solidified jelly, but it is now also produced by a patented process in pearls or solidified drops by forcing the glue extract through fine orifices into a liquid or gaseous medium. These droplets measure about 1 mm., are easily dried, and owing to the greater surface they present, a given quantity will take up water in much less time than when prepared in the older forms; moreover, the glue is more readily dried when prepared in this form than are the slabs.

Animal glue can be made insoluble by treatment with formaldehyde, but for the preparation of a water-resistant product it is preferable to employ finely divided paraform and oxalic acid in the proportions of 10 and 5 per cent. respectively on the weight of the dry glue used. The glue is soaked in a suitable quantity of water and then "melted," the mixture then added, and when the oxalic acid has dissolved, the glue is ready for use, and will remain so for some seven to nine hours at not exceeding 45° C. Thymol and beta-naphthol, among other substances, are used for the preservation of glue, and a firm in the U.S.A. has recently developed a new product for that purpose—viz., orthophenylphenol, the sodium salt of which has a high co-efficiency in respect of mould and putrefactive agents and is readily soluble in water.

References: C.T.J., July 11, 1924, and January 23, 1925; article on the "Manufacture of Bone Glues," by J. C. Kernot and N. E. Speer (*Ibid.*, 1926, **78,** 556, 572, and 689; *Ibid.*, 1926, **79,** 445); articles by A. J. V. Underwood (*Ind. Chem.*, 1925, i., 306); T. W. Jones on "Glue Testing" (*Ibid.*, 1925, i., 86 and 375); "Glue in Paper-making" (*C.T.J.*, 1928, **83,** 227); N. L. Wright (*Ind. Chem.*, 1927, iii., 51); *Glues and Glue Testing*, by S. Rideal (Scott, Greenwood and Son, London); *Glue and Gelatine*, by P. I. Smith (Sir Isaac Pitman and Sons, Ltd., London); Adhesives, Bones, Gelatin, and Isinglass.

GLUTACONIC ACIDS (Chemistry of)—Probably examples of *cis-trans*-stereoisomerism. (See J. F. Thorpe (*J.C.S.*, 1931, p. 1011).)

GLUTAMIC ACID (*a*-**Amino-Glutaric Acid**) ($CO_2H.CH(NH_2).CH_2$, $CH_2.CO_2H$)—Occurs naturally in beetroot and parts of some other plants, including the shoots of vetch and gourd. This acid and glutamine correspond with aspartic acid and asparagine. Sodium glutamate, a white non-poisonous crystalline salt, is made in China and Japan on a considerable scale and used as a condiment. (See *C.T.J.*, 1929, **85,** 373; Y. Takayma (*B.C.A.*, 1930, B, 753); and M. S. Dunn (with others) (*B.C.A.*, 1932, A, 150).)

GLUTATHIONE—See H. L. Mason on its spontaneous cleavage in aqueous solution (*J. Biol. Chem.*, 1931, **90,** 25); also Foods.

GLUTEINS—Vegetable proteins soluble in alkalies and allied to globulins.

GLUTEN or VEGETABLE ALBUMEN—The albuminoid or protein part of wheat flour, amounting to from 10 to 15 per cent. in the best qualities, and in inferior grades to from 8 to 9 per cent. It is that part of the flour which, when made into a paste and washed with water, constitutes the tenacious part as distinct from that portion which dissolves in the water and the starch which goes into suspension in the water. It is soluble in alkalies and in strong acetic acid.

Crude gluten may contain from 5 to nearly 20 per cent. of starch content as a filler. The lipoid content ranges from 5 to more than 10 per cent., and the ash varies widely. A soft red winter-wheat flour gluten contained 84·5 per cent. of protein, 47·5 per cent. of lipoids, 15·6 per cent. of ash, and 20·4 per cent. total phosphoric acid contained in the originating flour (D. B. Dill, *J.C.S. Abs.*, cxxviii., I., 622).

GLYCERIA WAX—See Waxes.

GLYCERIC ACID ($C_3H_6O_4$)—A thickish liquid resulting from the oxidation of glycerol (glycerine) by nitric acid; it enters into combination with the alkalies and other bases, forming salts known as glycerates.

GLYCERIDES—Esters in which the glyceryl constitutes the alcohol radical, as in triacetin, $C_3H_5(CH_3COO)_3$; tristearin, $C_3H_5(O.C_{18}H_{35}O)_3$; distearin, $C_3H_5(O.C_{18}H_{35}O)_2OH$; diacetin, $C_3H_5(O.C_2H_3O)_2OH$; diformin, $C_3H_5(O.CHO)_2OH$. The triglycerides occur in fats and oils, and mixed glycerides contain two or three different acid residues in each molecule. An approximately theoretical yield of glycerides can be obtained by heating a mixture of glycerol and fatty acids at a moderate temperature under reduced pressure (Belucci and Manzetti); a number of pure glycerides have been synthesized by Averill, Roche, and King (see *B.C.A.*, 1929, A, 539); the physical properties of pure triglycerides is the subject of an article by Joglekar and Watson (*J.S.C.I.*, 1928, **47,** 365 T); the separation of glycerides from a number of oils is dealt with by B. Suzuki and V. Yokoyama (*B.C.A.*, 1929, A, 1271).

GLYCEROL (**Glycerine**) ($C_3H_8O_3$ or $C_3H_5(HO)_3$)—A syrupy, colourless, and odourless liquid of a somewhat sweet taste, and sp. gr. 1·27. It is soluble in water and alcohol, solidifies to a crystalline condition when exposed to a sufficiently low temperature, m.p. 17·0° C., and b.p. 290° C. At 70° C. the liquid has a specific heat of 0·5537, and that of the crystalline solid is 0·3778. It is chemically described as a trihydric alcohol and is a product of the saponification of fats and oils. The alkali used for soap-making combines with the fatty acids to make soaps, while the glycerol passes into solution and is recovered from the lye, which contains about 5 per cent., 12½ per cent. salt, and some impurities. After concentration of the lyes to about 80 per cent. strength of glycerol and removal of the salt, distillation in steam at 190° C. gives weak glycerine or so-called "sweet waters," and this, after decolorization by carbon, is reconcentrated *in vacuo* to a sp. gr. of 1·262, or over 98 per cent., and used in the making of high explosives, such as dynamite; it is also marketed in crude form of 80 per cent. strength.

GLYCEROL (*Continued*)—

The recovery of glycerol from soap lyes is dealt with by E. T. Webb (*C.T.J.*, 1925, **77,** 507 and 619).

It is also produced by subjecting fats to the action of superheated steam, by which process they are hydrolysed, the glycerine passing over with the steam, leaving the fatty acids behind; or the fats can be hydrolysed by heating in water to which a small quantity of sulphuric acid has been added, with or without the addition of catalytic agents. (See "Twitchell" process, p. 335.) In such case, the fatty acids rise and float on the top of the liquid which contains the glycerol, and from which it can be easily recovered.

The latest development in the preparation of glycerol from the crude product, without the use of free steam, consists in passing the crude article at 180° C. in an atomized state by means of suitable jets into a vessel of higher vacuum, steam coils being used to maintain the temperature at about 180° C. with the aid of condensers and pumps as required.

The various commercial products are known as "chemically pure," "dynamite," "industrial white," and "pale straw" glycerines. The crude material often contains trimethylene glycol ($OH.CH_2.CH_2.CH_2.OH$), from 1 to 3 per cent., and even up to 10 per cent. at times, being the product of a *Schizomycetes* fermentation process. It boils at 216° C., has a sp. gr. of 1·0625 at 0° C., and resembles glycerol in its physical properties, although it is less viscous. It can be separated from glycerol by fractional distillation, and being hygroscopic, may be used in its place as a moisture-absorbing material, and in aqueous solution for the prevention of water freezing.

Precautions to be observed in the economic production of pure glycerol of high sp. gr. are dealt with in a paper by A. Rayner (*J.S.C.I.*, 1926, **45,** 265 T).

Glycerol has been obtained to some considerable extent in Germany, and more recently in the U.S.A., from molasses and sugar by a process of fermentation with a selected yeast (*S. ellipsoideus*) in an alkaline medium. The difficulties incidental to this process, and a promising method of treating the fermentation slop, are the subjects of a reference note in the *C.T.J.*, 1929, **85,** 419. Commercial sucrose, dextrose, lævulose, or invert sugar can be fermented with yeast in the presence of one or more inorganic or organic substances or alkaline reaction, such as di-sodium phosphate, sodium or ammonium carbonate, or sodium bicarbonate, with or without catalysts such as manganese or iron sulphate. The fermentation is preferably conducted in the presence of sodium sulphite, together with a small quantity of a hydrosulphite or sulphoxylate, and the yeast (previously cultured saké and wine yeasts being preferred) can be regenerated by a purifying fermentation in presence of dilute acid and used over again, together with a surplus yield, which can be employed for baking or fodder. In this way the yield of glycerol amounts to from 35 to 40 per cent. of the sugar.

One molecule of sugar should yield one molecule of glycerol and no alcohol when the fermentation is conducted in the presence of sodium bisulphite, which fixes the acetaldehyde; otherwise, two molecules of

GLYCEROL (*Continued*)—
sugar yield one of glycerol and one of alcohol. (See Y. Tomoda, (*B.C.A.*, 1930, B, 299).)

Attempts have been made to produce allyl alcohol (C_3H_6O) on an economical commercial scale, as glycerol can be readily obtained therefrom by oxidation.

Glycerol is largely used in the manufacture of nitro-glycerine and other explosives; in the preparation of perfumes, cosmetics, printing-ink rollers, lacquer solvents, liqueurs, fruit preservatives, blacking, synthetic resins; as a substitute for sugar in preparing marmalade and other food for diabetic subjects; as an "anti-freeze"; for dehydration of coal gas, etc.; and (when mixed with 5 or 6 parts water) as a lotion for chapped and sunburnt skins and for the quenching of steel. Although it can be distilled *in vacuo* or in the presence of steam without decomposition, it undergoes decomposition when heated in the air. Certain derivatives of glycerol, including its normal ethers, acetals, amines, and resins obtainable from glycerylamines, form the subject matter of papers by Fairbourne (with others) referred to below.

Glycerol never freezes at atmospheric temperatures, and is sometimes used, therefore, as a lubricant for delicate machinery.

Other references: Particulars of the various types of glycerol, their uses and substitutes in industry, by Drake and Lewis (*Chem. and Ind.*, 1928, **47,** 1073); "Glycerol Derivatives, Parts I. and II., by Fairbourne, Gibson, and Stephens (*Chem. and Ind.*, 1930, **49,** 1021 and 1069), and G. P. Gibson, Part III. (*Ibid.*, pp. 949 and 970); for glycerol tables (sp. gr. and per cent.) see Bosart and Snoddy (*B.C.A.*, 1927, B, 397, or *Analyst*, 1927, **52,** 434); "The Viscosity of Glycerin Solutions," by L. V. Cocks (*J.S.C.I.*, 1929, **48,** 579); and *Glycerol and the Glycols*, subject of a monograph by J. W. Lawrie (Chem. Catalog. Co., Inc., N.Y.).

GLYCEROPHOSPHORIC ACID ($C_3H_9PO_6$ or $C_3H_5(OH)_2H_2PO_4$) (sp. gr. 1·125)—A cleavage liquid product from complicated substances contained in the yolks of egg and certain phosphatic constituents of brain matter. It is soluble in water and alcohol, forms a characteristic compound with lead ($C_3H_7PbPO_6$), and is an ester of glycerol. It can be made from glycerol by action of phosphoric acid, and is used in medicine, as are also the glycerophosphates of calcium ($Ca(C_3H_8PO_6)_2$), iron, magnesium, potassium, sodium, etc. (See Thudichum and Kingzett (*J.C.S.*, 1876, ii., 20); Karra and Benz (*B.C.A.*, 1927, A, 2271); Hill and Pyman (*J.C.S.*, 1929, p. 2236); and Brain Matter.)

GLYCERYL—The trivalent radical $CH_2.CH.CH_2$ contained in fats. (See Fats and Glycerol.)

GLYCINE (**Glycocoll**) or **AMINO-ACETIC ACID** ($C_2H_5NO_2$)—Is a white, crystalline substance of sweet taste and m.p. about 234° C.; soluble in water, and behaves both like a base and an acid, forming salts. It can be prepared chemically by several methods, as, for example, by the hydrolysis of glycocholic acid, $C_{26}H_{43}NO_6 + H_2O = C_{20}H_{40}O_5$ (cholic acid) $+ C_2H_5NO_2$ (glycine), but it is especially interesting when con-

GLYCINE (*Continued*)—
sidered as a derivative of wool and silk and as a product of the hydrolysis of albuminous bodies, because it is believed that a mixture of amino-acids, together with sufficient amounts of fat, starch, sugar, and the necessary saline bodies, will maintain life without the use of proteins. A new method for its preparation is given by Boutwell and Kuick (*B.C.A.*, 1930, A, 1563), and its synthesis is the subject of a paper by Anslow and King (*J.C.S.*, 1929, p. 2463). (See Albumins, Amino-acids, Bile, Foods, Polypeptides, and Vitamins.)

GLYCOCHOLIC ACID ($C_{26}H_{43}NO_6$)—See Bile and Glycine.

GLYCOCOLL—See Amino-acids and Glycine.

GLYCOGEN ($C_6H_{10}O_5$)—An amylaceous or dextrin-like substance, presenting much similarity to starch, contained in yeast cells and the liver and placenta of animals. It combines with water to form a gummy body, and its aqueous solution rotates polarized light to the right four times as much as dextrose. It changes rapidly into *d*-glucose, and when boiled with dilute acids it is changed into maltose. As ordinarily prepared, it is impure and has a considerable phosphorus content. As a heart content it is stated to be lost during work and disappears when that organ is exhausted. Activity is retained the longer the richer the heart is in glycogen. (See Loeper (with others) (*B.C.A.*, 1930, A, 810) and K. M. Daoud and A. R. Ling (*J.S.C.I.*, 1931, **50**, 365 T).)

GLYCOL DINITRATE—See Nitro-glycol.

GLYCOLLIC ACID (**Hydroxyacetic Acid**) ($C_2H_4O_3$ or $CH_2OH.COOH$) occurs naturally in the juice of the sugar-cane, in unripe grapes and the leaves of the wild vine, and may be prepared in a number of ways, including the oxidation of glycol. It is a colourless, crystalline, deliquescent substance, which melts at 78° C., and is soluble in water and alcohol. It has attracted attention as a possible substitute for tartaric acid in dyeing and calico-printing, processes for its production being based upon the decomposition of trichlorethylene by alkali under autoclave conditions and upon the electrolytic reduction of oxalic acid. By the action of nitric acid it is converted into oxalic acid.

GLYCOLS—See Alcohols (Polyhydric), Ethylene Glycol, and Glycerol.

GLYCOLS (**Ethers**), such as $C_2H_4(OCH_3)_2$, are for the most part colourless liquids of ethereal odour, the diacetate constituting a good solvent of cellulose nitrate, and acetate. The glycol monoethyl ether is largely used in lacquer-making. (See J. G. Davidson (*C.T.J.*, 1926, **79**, 164).)

GLYCURONIC ACID ($C_6H_{10}O_7$)—A product obtained from saccharic acid by reduction with sodium amalgam.

GLYCYRRHIZIN—See Liquorice.

"GLYPTAL"—A synthetic resin of flexible and durable character made by heating a mixture of phthalic anhydride and glycerine. In various modified forms it is used as a base for finishing and protecting paints, varnishes, lacquers, and other surfaces, also for electrical insulating pur-

"GLYPTAL" (*Continued*)—
poses, and as a shellac substitute or binder for all rigid mica insulation. (See *C.T.J.*, 1930, **86**, 82, and L. K. Scott (with others), *B.C.A.*, 1931, **50**, B, 33; and H. H. Morgan (*C.T.J.*, 1932, **90**, 280).) Some products of this kind are now marketed under the name of "Paralac."

GNEISS—A laminated mineral of granite character containing mica.

GOA POWDER—See Chrysophanic Acid.

GOLD (Aurum, Au) **and its Compounds**—Atomic weight, 197·2; sp. gr., 19·32; m.p., 1,063° C.; crystal system, No. 1. Gold is widely distributed in nature, and is found for the most part in the free metallic condition in quartz veins and alluvial deposits resulting from the gradual disintegration of gold-bearing (older sedimentary or plutonic) rocks. It is extracted from quartz by crushing and amalgamation with mercury, and from alluvial deposits by mechanical washing with water, the water carrying away the lighter associated substances and leaving the heavier gold behind. When the amalgam process is used, the gold is obtained from the amalgam by distilling off the mercury, the gold being left behind.

There are other methods of extracting gold from its ores, including one used on a very large scale, in which potassium or sodium cyanide is the active agent employed. The crushed ore in a finely divided condition, or that from which the bulk of the gold has been already extracted by the amalgamation process, is treated with a solution of the cyanide containing from $\frac{1}{4}$ to 1 per cent. while freely exposed to the air. This dissolves the gold according to the equation (using sodium cyanide:

$$2Au + 4NaCN + O + H_2O = (2AuNa(CN)_2) + 2NaOH,$$

and is afterwards precipitated from the solution by passage through vessels containing metallic zinc dust or shavings or by electrolytic action (using lead-foil cathodes for that purpose) and subsequently fused.

When zinc is used for this purpose, the solution containing the gold in the form of a double cyanide undergoes chemical change as follows (when NaCN is used): $2(AuNa(CN)_2) + 2NaOH + Zn = 2Au + Zn(OH)_2 + 4NaCN$, or $2(AuNa(CN)_2) + Zn = 2Au + Na_2Zn(CN)_4$, excess of sodium cyanide being essential in this case. The gold is deposited on the zinc shavings, and can be purified from the zinc and other impurities by treatment with sulphuric acid or nitre cake, after which it is pressed, calcined, and melted down. (See J. S. Macarthur (*J.S.C.I.*, 1890, p. 267) and Ores.)

Gold is comparatively soft, yellow in colour, and the most malleable and ductile of all metals, admitting of being beaten into an extremely fine leaf form, which is used for gilding and other purposes. It can be beaten out into sheets so thin that 280,000 are required to make one inch in thickness. It is reported that 25 sheets of British leaf contain 5 grains of gold, while a similar number of Nuremberg (German) sheets contain only 3 grains. It can be prepared in colloidal form by several methods. (See H. Nicol (*J.S.C.I.*, 1927, **46**, 179 T, and 1928, **47**, 343 T); also M. O. Charmandarjan (*B.C.A.*, 1929, A, 1379).)

Gold is not attacked by acids, with the exception of aqua regia

GOLD (*Continued*)—

(nitrohydrochloric acid), in which it dissolves, forming auric chloride ($AuCl_3$).

Alloyed with copper and silver, it is largely used for coinage and other applications, including dentistry and the preparation of amalgams. Pure gold is described as 24-carat gold, whilst 18-carat gold consists of 18 parts of gold and 6 parts copper or silver. In this country the legal standard is 22-carat gold, and English gold coin consists of 11 parts gold and 1 part copper.

"Gold amalgam" (Au,Ag,Hg) is a mixture of gold, silver, and mercury containing about 40 per cent. gold.

Electro-gilding of other metals is carried out by using a solution of the double cyanide of gold and potassium ($AuK(CN)_2$). (See article by Arma (*C.T.J.*, 1932, **90**, 309), and Electricity, p. 292.)

Aurous oxide (gold suboxide) has been represented as having the formula Au_2O, but chemical evidence of its existence is wanting. (See W. B. Pollard (*J.C.S.*, 1926, p. 1347).)

Auric or gold oxide (Au_2O_3) is a brown powder, insoluble in water, and combines with ammonia to form a substance of indefinite composition named *fulminating gold,* which explodes easily when heated to 100° C. or struck with a hammer.

There are two chlorides (AuCl and $AuCl_3$), both of which are soluble in water, the latter being the more important. It is formed when gold is dissolved in aqua regia, or by the action of chlorine on gold leaf, and can be obtained in yellowish-red crystals having the composition $AuCl_32H_2O$, which lose their water of crystallization upon heating and change to a brown mass. This trichloride is used in photography and gold-plating.

The double chloride, gold-potassium chloride ($AuCl_3.KCl,2H_2O$), is a soluble yellow, crystalline salt used in photography and painting porcelain and glass.

Certain organic compounds of gold are described by Gibson and Simonsen (*J.C.S.*, 1930, p. 2531). (See Purple of Cassius.)

GOLDBEATER'S SKIN—Peritoneal membrane from the intestinal tube of the ox and other animals, soaked in a weak solution of potash; after washing it is stretched and beaten out with a hammer, and finally treated so that it cannot undergo putrefaction.

GOLDEN SULPHIDE—See Antimony and Schlippe's Salt.

GOMMIER RESIN—See Gums and Resins, p. 425.

GONAKIE (*Acacia Adamsonii*)—Found in Southern Mauritania and Northern Senegal, the pods of which produce a tanning material useful as a substitute for sumac.

GONIOMETER—An instrument for measuring the angles between the faces of crystals.

GOOCH CRUCIBLE—See Crucibles.

GOOSE FAT is stated to have m.p. 29° to 31° C.; sap. v. 192·6; and i.v. 72·77. It separates on long standing, the solid part of which has

GOOSE FAT (*Continued*)—

an iodine value of 52·3, and makes up 15 per cent. of the whole, while the liquid part has an iodine value of 77, and consists mainly of triolein. Another report gives the stearic acid content as 3·8 per cent., palmitic acid 21·2 per cent., and oleic acid 72·3 per cent.

GOSSYPIUM—See Cotton.

GOULARD WATER—A very dilute solution of lead acetate used for bathing weak eyes, etc.

GRAINS (Brewers')—See Beer and Wheat.

GRAINS OF PARADISE (Melleguetta or **Guinea Pepper)**—The fruit of certain zingiberaceous plants (*Amomum melleguetta*) grown in Ceylon and on the western coast of Africa; used as a condiment and in medicine.

GRAM-ATOMS—The atomic weights of elements expressed in grams.

GRAM-EQUIVALENTS—The atomic weights of elements divided by their valencies.

GRAMME (Gram, Grm.)—See Weights and Measures.

GRANITE—Rocks of felspar and mica in a mass of quartz, often associated with other minerals; m.p. variously given as 1,100° and 1,240°.

GRAPE-SEED OIL is a yellow, fixed, edible oil of pleasant odour and taste expressed or extracted from the seeds of *Vitis vinifera;* yield 9 to 12 per cent. from fresh pips or 15 to 17 per cent. in the dry state. It has a solidifying-point of $-10°$ to $-13°$ C.; m.p., 24° C.; sp. gr., 0·92 to 0·935; sap. v., 178 to 180; ref. ind., 1·4713 at 25° C., and i.v., 94 to 96·5. It is soluble in benzol and carbon disulphide, and used as an illuminant, lubricant, food, for soap-making, also as a substitute for castor oil in respect of some applications, although liable to speedy rancidity.

As obtained from the United States Concord grapes, the oil has been given the following values: sp. gr. at 25° C., 0·9204; solidifying at $-22°$ to $-24°$ C.; sap. v., 192·2; and i.v., 135·8; containing 53·6 per cent. linolin, 35·9 per cent. olein, 5·2 per cent. palmitin, 2·2 per cent. stearin, and unsaponifiable matter 1·6 per cent. It is stated to be, when refined, as good as soya-bean oil, and can be used for making oleomargarine, also for admixture with linseed oil in paint-making.

Later information concerning the expressed oil and the extracted product is given by Jamieson (with others) (*B.C.A.*, 1930, B, 621).

GRAPE SUGAR (GLUCOSE)—See Dextrose, Glucose, Sugars, and Carbohydrates.

GRAPHITE—See Carbon (p. 138) and Kish.

GRASS—See Ensilage and Paper.

GRASS OILS—Volatile essential oils, including citronella oil, lemon grass oil, geranium oil, ginger grass oil, etc., derived from a number of different plants.

GRAVITATION is ordinarily defined as the force which mutually attracts all masses of matter.

Kepler is credited with having discovered the mathematical laws by which the planets are balanced in space, and according to the law of

GRAVITATION (*Continued*)—
gravitation, the weight of a substance is the measure of its attraction by the earth. In other words, weight is defined as an acquired property of matter produced by an attractive force emanating from the centre of the earth. Weight diminishes with distance from the earth, so that a mass of lead weighing 1,000 lbs. at sea-level weighs 2 lbs less at a height of four miles. The force of gravity carries a pendulum in swing over to the dead-point and brings it back again almost to the starting-place, and by counting the beats in a given time subject to certain corrections and precautions, the variations in gravity at different places are ascertained.

The intensity of gravitation is inversely as the square of the distance of the gravitating body, and the attraction between the earth and a mass weighing 1 gram is expressed as 980 degrees.

Some forty-two theories have been propounded to account for gravitation, and, among these, adhesion (as between two clean plates of metal), cohesion, and capillary attraction, all which have been viewed in common as manifestations of magnetic force; but while no fact has at present been found which is necessary for the absolute substantiation of any of them, it is thought that the further study of atoms and their structure will throw light upon the true nature of gravitation.

The fall of an apple from tree to earth, the tidal waves, the courses of the planets round the sun, and the movements of all the heavenly bodies have been in the past attributed to gravitation, but Einstein states that gravitation as a force has now been abandoned. According to the claim recently made, light in common with matter is subject to gravitation, but against this view it may be urged that it is the attenuated material matter occupying space which conveys the light that is really deflected. (See Light and Relativity.)

GRAVITIES—See Densities, Specific Gravity, and Hydrometer.

GREASES—Axle greases are of two classes—viz., those consisting essentially of calcium resinate dissolved in rosin oil, and lubricating mixtures being solid or semi-solid emulsions of fats, fatty oils, mineral oils, and rosin oils, with lime-soda or metallic soaps. (See Lubricants.)

GREEN OIL—A heavy crude fraction of creosote oil containing anthracene, chrysene, carbazole, etc., distilled from coal tar, from which the anthracene and associated bodies can be separated by cooling. (See Coal.)

GREEN VITRIOL (Green Copperas)—Common name for ferrous sulphate.

GREENOCKITE—See Cadmium.

GREY ANTIMONY ORE (Stibnite)—See Antimony.

GRIGNARD REAGENTS—Organo-metallic compounds of magnesium, such as magnesium methyl iodide.

GRINDING (Milling)—There are three main types of mills—viz., the "disc," "roller," and "beater-wheel." *References:* A paper on "Modern Grinding," by J. C. Farrant (*C.T.J.*, 1931, **88**, 97), concerning "actual operating data on different materials to indicate the fields in

GRINDING (*Continued*)—

which different classes of mills can be most efficiently applied"; S. G. Ure (Part I., *Chem. and Ind.*, 1924, **43**, 1144; Part II., *Ibid.*, 1925, **44**, 321 and 349; Part III., *Ibid.*, 1925, **44**, 551); G. Martin (*J.S.C.I.*, 1926, **45**, 160 T); *B.C.A.*, 1927, B, 623; G. Martin (*C.T.J.*, 1926, **78**, 61, and 1926, **79**, 196); C. J. Seaman on "Modern Grinding Mills" (*C.T.J.*, 1925, **76**, 422); C. S. Messenger on "Air Separation in Grinding and Pulverizing" (*Ibid.*, 1925, **76**, 451); The Miracle Mills (*Ibid.*, 1924, **74**, 593, and 1932, **90**, 90; *Chem. and Ind.*, 1932, **51**, 153); "The Colloid Mill" (*C.T.J.*, 1924, **74**, 619); "The Torrance Super-Grinder" (*Ind. Chem.*, 1928, iv., 387); "The Alfa-Laval Homogeniser" (*Ind. Chem.*, 1930, vi., 433); "The Disc Bar Mill" (*Chem. and Ind.*, 1931, **50**, 254, and *Ind. Chem.*, 1931, vii., 173); R. W. Kendall on Modern Ball and Pebble Mill Technique (*C.T.J.*, 1932, **90**, 191); "Fine Grinding Machines," by J. W. Hinchley (*J.S.C.I.*, 1926, **45**, 341 T); "A Screenless Hammer Mill," by A. Salmony (*Ind. Chem.*, 1929, v., 486); descriptions of the Plauson mill, the Premier mill, and the "Hurrell homogenizer," by A. S. Wilson-Jones (*Ind. Chem.*, 1925, i., 41); C. H. Möllering (*B.C.A.*, 1930, B, 743); "The 'Kek' Mill" (*Ind. Chem.*, 1926, ii., 131); "The 'Conquest' Mill of the Ring-Roll Type" (*Ind. Chem.*, 1928, iv., 168); F. de M. Tubman on Grinding and Sifting (*Chem. and Ind.*, 1932, **51**, 330); Hartland Seymour on *Crushing and Grinding Machinery* (E. Benn, Ltd.); Disintegrators, Mixers, Plauson's Colloid Mill, and Premier Mill.

GRINDSTONE—A highly cemented, tough, natural sandstone.

GROUND-NUT OIL—See Arachis Oil.

GUAIACOL (**Monomethyl-Catechol**) $C_7H_8O_2$ or $C_6H_4(OH)(OCH_3)$—A phenolic compound found present in beechwood tar, and produced with other substances by the dry distillation of guaiacum resin. A process designed by M. Azaretti obtains it from anisidine sulphate by diazotization and decomposition of the diazo-sulphate in presence of copper sulphate, with a yield of 72 to 73 per cent. (See Guaiacum.) It is a colourless, refractive, inflammable, oily body of peculiar faint odour, reminding of creosote; sp. gr. 1·1395, m.p. 28·2°, and b.p. 205° C.; soluble in water and alcohol, and used for treatment of rheumatoid arthritis, also for making coumarin and vanillin.

GUAIACYL CARBONATE (Duotal) ($C_{15}H_{14}O_5$ or $(OCH_3.C_6H_4.O)_2CO$) —A white, crystalline powder soluble in alcohol and ether; used as a non-irritating preparation in the treatment of phthisis, diarrhœa, and typhoid fever, acting as an antipyretic and antiseptic.

GUAIACUM—A resinous exudation from incisions made in the stems of the *Guaiacum officinale* of the N.O. Zygophyllaceæ, growing in Jamaica and other West Indian Islands, the hard lignum wood of which is largely exported from Cuba and Hayti. It is soluble in alcohol, acetone, and ether, acts as a mild laxative and diuretic, and is used in the form of lozenges and pastilles for throat troubles, also in varnish-making. An optically active substance named guaiaretic acid ($C_{20}H_{24}O_4$) has been isolated from the resin. (See Guaiacol and Lignum Vitæ.)

GUAIAC-WOOD OIL—A thick, viscid oil, apt to become crystalline, distilled from the wood of some species of guaiacum, known as "balsam wood," and "holy wood" in South America. It is soluble in alcohol and ether, has a sp. gr. of about 0·96 to 0·98 at 15° C., opt. rot. $-6°$ to $-7°$ at 20° C., and is used in perfumery.

GUANIDINE (**Imino-carbamide**) ($NH:C(NH_2)_2$)—A crystalline substance, soluble in water, obtainable by various processes, and which yields urea and ammonia upon hydrolysis, $CN_3H_5 + H_2O = CON_2H_4 + NH_3$. (See Urea.)

GUANO—Excrement of sea-fowl from islands near the coast of Peru and Chile and elsewhere, consisting largely of calcium phosphate, and used as a fertilizer. (See Coprolites and Fertilizers.)

"GUARDAX"—A non-splinterable safety glass.

GUAVA—The fruit of *Psidium guajava* (Linn., N.O. Myrtaceæ). Various species occur in S. America, E. and W. Indies, China, etc., in which the proportions of flesh, seed, and pectic juice vary very much.

Specimens give from 58 to 85 per cent. flesh, and the flesh contains proportions of glucose, lævulose, and sucrose.

An oil is contained in the seeds (about 8·4 per cent.), which has a sp. gr. at 15°/15° C. of 0·9274, i.v. 131·1, and sap. v. 197·1.

GUIGNET'S GREEN—A hydrated sesquioxide of chromium of indefinite composition, made by fusion of potassium dichromate with boric acid followed by decomposition with water; used as a mineral pigment.

GUMS and RESINS—The generic names of a number of viscid or dry vegetable, gummy products—that is to say, more or less sticky—(such as gum arabic, gum tragacanth, seaweeds, lichen gums, and pectin gums) some of which are of the nature of carbohydrates. Others are really resins or mixtures of gums and resins; the real gums only are soluble in water; some of them yield pentose sugars when hydrolysed, and mucic and oxalic acids upon oxidation with nitric acid. They are sometimes regarded as of three classes—viz., those which, like gum arabic, contain arabin (including gum Senegal, Suakin (Talka) gum, and Morocco (Barbary) gum); others which, like gum tragacanth, contain a principle named bassorin as well as arabin, and the more definite resins of the copal and other classes, although generally styled gums, are separately described under their distinctive names.

A rapid identification method for differentiating gums soluble in water is given in the abstract of an American paper (*C.T.J.*, 1929, **84**, 608). See also Jacobs and Jaffe (*Ind. Eng. Chem.* (*Anal.*), 1931, **3**, 210). Further details respecting resins will be found under the heading of Balsams.

Accroides (**Black-Boy Gum**)—A resin from Xanthorrhea trees, indigenous in Australia; soluble in alcohol, and used in varnish-making.

Ammoniacum is really a natural resin obtained from the *Dorema ammoniacum* of N.O. Umbelliferæ, a native of Central Persia.

Animé is of several varieties (East Indian, Zanzibar, West Indian, and South American), and is used in making varnishes; sp. gr. 1·06, and m.p. 240° to 250° C. The *Vateria indica* of the N.O. Dipteraceæ

GUMS AND RESINS (*Continued*)—

furnishes an Indian variety of copal. The West Indian variety is the product of a tree known as the *Hymenæa Courbaril* of the N.O. Leguminosæ, a native of New Spain and Brazil. (See Gum Copal and Gum Zanzibar.)

Arabic (**Acacia**) is the dried juice from the bark of *Acacia arabica* and other species of *Acaciæ* which flourish in Arabia, Egypt, the Soudan, and Senegambia, and *Acacia decumins* indigenous in Australia, the gum known as Cordofan being esteemed the best. It dissolves slowly in water, and consists mainly of a mixture of alkali arabinates, the arabinic acid comprising a combination of a simpler acid named arabic acid in association with two sugar-like bodies named arabinose and galactose. The formula as follows generally represents the combination named arabinic acid:

$$\underbrace{2(C_{10}H_{16}O_8)}_{\text{Arabinose.}},\underbrace{4(C_{12}H_{20}O_{10})}_{\text{Galactose.}}\underbrace{C_{23}H_{30}O_{18}}_{\text{Acid Group}}.$$

According to L. Amy, gum arabic contains a water-insoluble substance which remains as a gel when a solution in cold water is subjected to dialysis. (See *B.C.A.*, 1928, A, 1408.) As to the constitution of this gum, see Butler and Cretcher (*Analyst*, 1929, **54**, 447) and A. G. Norman (*Ibid.*, 549). It is used not only as an adhesive, but also as a demulcent in the preparation of a number of pharmaceutical and chemical emulsions; also for thickening ink, in the manufacture of blacking, and in calico-printing. Upon hydrolysis it is said to yield a so-called aldobionic acid. (See Challinor, Haworth, and Hirst (*J.C.S.*, 1931, p. 258).)

Australian, or Wattle Gum, exuded from several species of acacia, yellow to reddish-brown in colour.

Asafœtida—A resinous gum extracted from the root of *Ferula asafœtida,* an umbelliferous plant which grows in Thibet, Persia, West Afghanistan, and Turkestan. It has a strong, offensive, onion-like odour, is much more soluble in alcohol than water, and upon distillation with water yields about 3 per cent. of a sulphuretted volatile oil of sp. gr. 0·975 to 0·990, opt. rot. $+10°$ to $-36°$, and ref. ind. 1·4940 to 1·5260, to which its odour is due. It acts as a powerful antispasmodic, and is used in hysterical cases and flatulent distension of the bowels.

Barbary—Product of the African (Morocco) *Acacia gummifera.*

Bassora—From the *Acacia leucophlæa.*

Benzoin is a resin which flows from the hacked bark of *Styrax* or *Lithocarpus benzoin,* N.O. Styracaceæ, a tree that grows in Sumatra, Borneo, Java, and Siam.

It has a pleasant smell, melts when heated; is soluble in alcohol, ether, and carbon disulphide; and is a mixture of several resins containing benzoic and cinnamic acids, which can be dissolved out of it by boiling water, or extracted to some extent by heating (sublimation). It is used as a source of the acids it contains and in varnish-making.

British—See Dextrin and Starch.

GUMS AND RESINS (*Continued*)—

Canada—See Balsams.

Cannabis—A resin from Indian hemp (*Cannabis Indica*), containing an active principle of narcotic character (hashish). (See R. S. Cahn (*J.C.S.*, 1930, p. 986, and 1931, p. 630).)

Cape—From the *Acacia horrida* (Willd).

Convolvulin—See Convolvulin, p. 234, and Scammony, p. 427.

Copaiba—See Balsams and Copaiba Oil.

Copal (**Cowrie, Animé**) is the name given to several resins which exude naturally from a number of trees, including the *Rhus copallina* of North America, the *Elæocarpus copalifer* of the East Indies, and the *Hymenæa verrucosa* of Madagascar. The Zanzibar gum is of both fossil and recent character. The Macassar (Manila) variety is said to be of better quality than the Indian copal from Singapore and the Philippines. The lumps of this hard resin, which is used in making high-quality copal coach varnish and cements, are yellowish in colour, hard, have a lustrous appearance, and easily fracture. The varieties can be identified to some extent by microscopic examination. They differ in their melting-points (150° to 315° C.) and solubilities in various liquids such as alcohol and turpentine oil, and by exposure to the air they absorb oxygen and become more soluble. The solubility is increased by melting the copal at the lowest possible temperature. (See A. F. Suter (*C.T.J.*, 1929, **84**, 255); Gum Manilla and Varnishes.)

Cowrie—See Gum Kauri and Gum Copal.

Dammar (**Dammara Resin**) of commerce melts at about 120° C., and is of two varieties, one of which is known also as "cowdie gum," the product of a large conifer (*Dammara australis*), which occurs in whitish-yellow masses and smells like turpentine. The better known one, of East Indian origin, known also as "cat's-eye resin," of resinous odour, comes in the main from Singapore, and is the product of another coniferous tree (*Pinus dammara* or *Dammara alba*). Both kinds are soluble in turpentine, alcohol, and ether, and are used in the manufacture of sticking-plasters, varnishes, and lacquers.

Black dammar is a black, resinous exudation from *Canarium strictum* Roxb., native of S. India, m.p. 110° C.; used in making bottling wax, varnishes, and as a substitute for Burgundy pitch. It yields on distillation a deep blue oil (80 to 85 per cent.) and a combustible gas (6 to 7 per cent.), the colour of the oil being attributed by K. L. Mondgill to a body named azulene. The resin is partly soluble in alcohol and quite soluble in benzene and turpentine.

Malayan Dammar Penak is a product of the State of Negri Sembilan. (See Penak Resin.)

Dragon's Blood—See Balsams, p. 78.

Elemi is an East and West Indian resinous product from various terebinthinous trees, including the pitch-tree, Arbol de la Brea, a native of Manilla, and the *Amyris elemifera* (Dutch Settlements); used in making varnishes and lacquers. Manilla elemi is colourless and honey-

GUMS AND RESINS (*Continued*)—

like in character and of aromatic odour. It yields about 10 per cent. of elemi oil containing one of the higher terpenes.

Euphorbium—Resin from *Euphorbia resinifera* of Mexico, used in medicine. (See Schmid and Zackerl (*B.C.A.*, 1931, A, 625) and Bauer and Schröder (*B.C.A.*, 1931, A, 847).)

Galbanum—A resinous body of sp. gr. 0·905 to 0·995 from the umbelliferous *Babon galbanum* or *Ferula galbaniflua,* imported from the Cape and Persia in hardened tear-like drops of light green colour and aromatic odour. It is used in medicine.

Gamboge—A gum resin from the *Stalagmites cambogiodes* tree and allied species of the N.O. Guttiferæ, which grow in Cambodia, Siam, and Ceylon. It is obtained by extraction from the leaves and twigs with boiling water, and concentration of the extract until upon cooling it sets into a cheese-like mass, after which it is cut up, sun-dried, and smoked. It is a tanning material, and acts as a drastic purgative, but as prepared in cakes for the market it is chiefly used as a pigment for water-colour painting and colouring varnishes.

The Asaban gambier is an improved product containing about 58 per cent. tannin, and is superior to the older "Cube gambier," which contains a proportion of screened rice-bran and is not so rich in tannin.

Ghatti—The product of *Anogeissus latifolia* (India and Ceylon), resembling gum acacia, and of great hardness.

Gilead (Mecca)—See Balsams, p. 78.

Guaiacum—See Guaiacol and Guaiacum.

Gommier—Product of *Dacryodes hexandra,* resembling in many respects "Manilla elemi," and derived from species of *Canarium.* It is soluble in alcohol, chloroform, ether, and turpentine, but almost insoluble in light petroleum. This Dominican resin dissolved in turpentine gives a "tacky" product.

Kauri—An amber-coloured product of the kaurie pine (*Agathis* or *Dammara australis*) of New Zealand. As distinct from the fossil kauri gum, which is dug in lumps from and near the surface of the ground, as also at some depth, the recent gum is obtained by bleeding (tapping) the trees. The gum is also now being extracted from the broken limbs and roots of trees strewn on the fields by means of solvent action, using alcohol and benzol (R. G. Israel, *C.T.J.*, 1931, **88,** 290). There is a large deposit of kaurie gum peat in the soil of the buried kauri forest in New Zealand, and a considerable industry is carried on in the extraction of this "chip" gum and associated oils. A ton of the peat yields about 10 per cent. of gum and gives by distillation about 64½ gallons of oil, from which motor spirit, a solvent oil, a turpentine substitute, and paint and varnish oils are extracted. The sp. gr. of kaurie is 1·05 and the m.p. about from 182° to 232° C.; it is used in linoleum and varnish making and the preparation of dental compounds. The New Zealand production in 1925 was 5,069 tons. Other species are produced in the Fiji Islands, New Hebrides, and Australia. An attempt

GUMS AND RESINS (*Continued*)—

to estimate and compare the constituents of kauri resins of various ages has been made by J. R. Hosking (*B.C.A.*, 1929, p. 754). (See also Gum Copal, and Kauri Oil.)

Kawa (**Kava**)—Extracted from the kauri-root (*Piper methysticum*) with a 10 per cent. solution of sodium hydroxide, from which yellow leaflets of so-called "Kawa-ate" can be prepared. It contains an acid crystalline body ($C_{13}H_{12}O_3$), which melts at 164°to 165° C., and is used in medicine. (See Borsche and Bodenstein (*B.C.A.*, 1929, A, 1453), and Borsche and Blount (*B.C.A.*, 1931, A, 89).)

Kino—See Kino.

Locust Kernel—See Locust Kernel.

Manilla (**Manila**)—A copal variety of resin from the *Agathis alba* Foxw., found in the Philippines, Malaccas, Borneo, Sumatra, and New Guinea; sp. gr. 1·06, and m.p. from 230° to 260° C.; soluble in alcohol and ether, and used in making paints and varnishes. (See Gum Copal.)

Mangostin (resin), from the bark of *Garcinia Mangostana* L., soluble in benzene, m.p. 180° to 181° C. (See I. O. Dragendorff, *B.C.A.*, 1930, A, 1578.)

Mastic—The name of a resinous exudation obtained from incisions made in the bark of the *Pistaci lentiscus* (N.O. Terebinthaceæ), growing on the Morocco coast, also in Chios and other islands of the Grecian Archipelago. It occurs in the form of small, yellow, translucent tears; is soluble in alcohol, acetone, and turpentine; and is used, among other applications, for making lacquer, plaster, varnish for maps, prints, etc.; for stopping teeth, and as a chewing-gum.

N.B.—The same name (*gum mastic*) is used to designate some forms of bitumen. (See Asphalt.)

Myrrh—Exudes from the stems of *Balsamodendron*, of the N.O. Amyridacæ, which grows in Arabia, Abyssinia, and Somaliland. It is associated with a volatile oil in common with other similar exudations from terebinthaceous shrubs, and is found in commerce in the forms of tears or pieces of irregular form, yellowish or red in colour and balsamic in odour. The best quality is known as *Turkey myrrh*. Tincture of myrrh is mildly disinfectant and astringent, and used as a local stimulant to mucous membranes. Myrrh is also used as a constituent of tooth powders. The oil distilled from the gum (myrrh oil) is of sp. gr. 0·988 to 1·007, is soluble in alcohol and ether, and used in perfumery, the yield being from 2·5 to 6·5 per cent.

Nauli—This is an oleo-resin from the Solomon Islands, somewhat sticky and having an odour of aniseed. It contains 2·5 per cent. water, 10·24 per cent. volatile oil, and 81·8 per cent. resin; the oil being reported useful as a substitute for anise oil, although of lower flavouring power, while the resin can be used in place of ordinary resin.

Olibanum (**Frankincense**) is obtained from incisions made in trees of the terebinthaceous order (*Boswellia carterii* and other species)

GUMS AND RESINS (*Continued*)—

indigenous in Somaliland and South Arabia; used in perfumery and as incense, also for fumigating, its odour being obnoxious to mosquitoes and other insect pests. This gum (sometimes misnamed as Gum Thus) yields an oil, by distillation, of a terpene character, sp. gr. 0·875 to 0·885, and soluble in alcohol, ether, etc.

Olive—A resin which yields 50 per cent. of a substance named "Olivil." (See B. L. Vanzetti, *B.C.A.*, 1929, A, 1064.)

Opopanax is obtained from the roots of *Pastinaca opopanax,* growing in Persia and other warm climates and used in perfumery. Associated with the resinous gum is an essential oil yielded by distillation to extent of about 6·5 per cent. The dried juice is brought in lumps from Persia, Turkey, and the East Indies, and has a peculiar odour and bitter taste.

Penak—See Penak Resin.

Peru—See Balsams, p. 78.

Podophyllin—See Podophyllin.

Pontianic (**Pontianak, Jelutong**)—Extracted from Jelutong rubber, the product of the forest trees *Dyera*, the chief variety being *D. costulata,* indigenous in Borneo, Sumatra, the Malay States, and some desert parts of Mexico, and contained to about 35 to 49 per cent. It can be extracted with acetone, has a sap. v. 105·72, is used to some extent in the rubber manufacture and as a chewing-gum, and promises to be of value in making size for paper. (See J. S. Remington, *Ind. Chem.*, 1925, i., 467.)

Sandarach (**Sandarac**)—A brittle yellow gum-resin of a faint odour which exudes from a coniferous tree growing in Morocco and Barbary, named *Callitris quadrivalvis* (N.O. Coniferæ); it is stated to contain several acids, including callitacpic acid ($C_{20}H_{30}O_3$), of m.p. 263° C.; is soluble in alcohol and ether, and used in lacquer and varnish making, also in dentistry. The wood is very durable and valuable. The examination of a sample (from *Callitris quadrivalvis*) by Balaš and Pejšová revealed the presence of *d*-*a*-pinene and *d*-limonine, a sesquiterpene alcohol, and a di-terpene, among other substances (*B.C.A.*, 1930, A, 1223). (See also T. A. Henry, *J.C.S.*, 1901, **79,** 1144.)

Scammony—A purgative gum-resin extracted by alcohol from the species of convolvulus (*Scammonium*) which grow in the Levant, Asia Minor, and Syria, the active principle of which is a glucoside resembling jalapin. Most of the commercial resin now comes from the Mexican scammony root (*Ipomœa orizabensis*, Ledanois). (See Corfield and Rankin, *Pharm. J.*, 1931, **127,** 76.)

Senegal is obtained from a species of acacia in the French colony of Senegal, and makes a stronger mucilage than gum arabic (acacia). It is the variety of acacia gum that is used in medicine, also for thickening the colours and mordants used by calico-printers.

Shellac—See Shellac.

Storax—See Balsams.

GUMS AND RESINS (*Continued*)—

Thus—A resin not soluble in water. (See Frankincense and Turpentine.)

Tolu—See Balsams, p. 78.

Tragacanth is a mucilaginous exudation of pathological nature (probably caused by insect life) from the *Astragalus gummifer* and *A. microcephalus* trees, which grow in Armenia, Turkey, Syria, and Persia. It swells up in water, and half of it is soluble, and the other part, consisting of starch, etc., also dissolves, or mostly so, upon boiling. It is graded into from "firsts" to "fifths" according to quality, contains about 53·3 per cent. arabin, and is used in medicine, by pharmacists for making emulsions, in calico-printing, and for stiffening rough cloth materials, etc. According to A. G. Norman, uronic acid units constitute about one-half of the molecule, arabinose being the only sugar found. (See *B.C.A.*, 1931, A, 535; also *Biochem. J.*, 1931, **25**, 200.)

The cherry-tree furnishes a somewhat similar gum. (See *C.T.J.*, 1927, **81**, 520.)

Tragon—Prepared from the carob bean; used in the leather industry and as a thickener for certain sauces, etc. (See Locust Kernel.)

Yacca is a red or yellow resin from *Xanthorrhœa hastilis* of Australia. It is soluble in alcohol, but insoluble in turpentine, linseed oil, benzol, and hydrocarbon solvents generally, but dissolves readily in aqueous caustic alkaline solutions to deep red solutions, from which it can be reprecipitated by acids in a yellow flocculent form. It contains phenolic bodies, and can be used as a source of picric acid, of which it can be made to yield 15 per cent.; it has also been used in the manufacture of dyes, and is said to be of importance in the manufacture of linoleum, dyestuffs, and photographic chemicals.

Zanzibar—This particular variety of gum animé is stated to contain 80 per cent. of a substance named trachlolic acid ($OH.C_{54}H_{85}O_3COOH$).

For detailed uses of the vegetable gums in medicine and industry, see S. R. Trotman (*C.T.J.*, 1928, **83**, 225); also Pectins and Seaweeds.

Ester Gums, such as Abrac, are substitutes for some of the harder natural resins. They are soluble in amyl acetate, some oils, turpentine, carbon tetrachloride, etc., have acid values from 2 to 150, and are stated to be much more suitable than ordinary resin for use in making certain varnishes and enamels. To prepare them, the softer parts of the acid resins are removed by distillation in a vacuum or a current of superheated steam, and the residue is heated with an equivalent proportion of glycerol, phenol, or naphthol to a high temperature with a dehydrating agent. According to F. M. Beegle, using resin and glycerine, an autoclave is not necessary; an aluminium vessel may be used without vacuum or pressure, and a proportion of wood oil facilitates the speed of reaction.

Resin esters can be formed with glycerol by heating together at from 280° to 300° C., and passing a current of hydrochloric acid gas, carbon dioxide, or air through the mixture.

GUMS AND RESINS (*Continued*)—

Ester gums are used in making enamel paints, cellulose lacquers, and more particularly (in conjunction with tung oil) for waterproof varnishes for boats, yachts, etc., and for electrical insulation. (See "Abrac.")

The resins as a class are uncrystallizable vegetable products which are insoluble in water, thus distinguishing them from gums (properly so called). They soften, as a rule, upon heating, and are more or less soluble in alcohol, ether, benzine, turpentine, and other solvents. The dullness of resins has been attributed to the penetration of water. Many of them are exudations from living trees, and some of these are supposed to result from oxidation of the volatile or essential oils which are secreted by them. These exudations are sometimes artificially facilitated by incisions made in the trees, as in the case of crude turpentine.

Others, such as amber, are of fossil origin, but have been probably produced by similar natural processes, while many others are extracted from plants by the use of solvents such as alcohol, benzine, or volatile oils. They are mostly yellow or brown in colour; some are hard (like Zanzibar) and fracture easily; others are soft, such as manila; and some become electric when rubbed. Descriptions of them individually will be found under their several names or under the preceding matter or heading of Balsams.

The resins are largely used in making lacs, varnishes, rubber substitutes, etc.

Common Resin (**Colophony Rosin**) is the residuum consisting chiefly of abietic acid left behind in the retorts when crude turpentine (as it exudes from the pine-trees which yield it and varieties of which are known also as galipot and *gum thus*) is distilled. It is graded according to colour, from B, the darkest, to WW, the lightest, and is largely used in various industries, such as process engraving, sizing paper, oilcloth and linoleum making, and particularly in soap-making, having the property of combining with alkalies, thus forming a kind of soap. The neutralization value of resin depends upon the variety, ranging from 131 to 181, the sap. v. from 146·8 to 194·3, and the i.v. from 55 to 184. The sap. v. of American resin ranges from 170 to 180, and the i. v. is about 122. All these values are alleged to suffer change if the resin be kept in powdered form in closed retainers.

It has weak acidic properties, sp. gr. of 1·07, m.p. 132° C., is easily soluble in turpentine and many other organic solvents, and can be obtained in a crystallized state, after careful drying, from a solution in petroleum naphtha. According to one account, American resin consists of three isomeric forms of abietic acid, amounting in all to some 81 per cent., substances described as resenes 10 per cent., essential oils and bitter principles 0·5 per cent., and impurities 0·5 per cent., abietic acid being given the formula $C_{20}H_{30}O_2$.

When resin is subjected to destructive distillation by heat, it is *cracked* or split up into a number of products, including "rosin spirit" and "rosin oil," which pass over with the vapours and are condensed, whilst a pitch is left behind in the retorts. When heated together with Japanese acid clay, a distillate containing some petroleum hydrocarbons

GUMS AND RESINS (*Continued*)—

is said to result. Okume resin, an oleo-resin from a tree native to Spanish Guinea, somewhat resembles colophony. (See Tomeo and Garcia-Viana, *B.C.A.*, 1930, B, 570.)

Other references: Filipovich and Vuisotzki on the "Distribution and Properties of Resinous Substances in Various Parts of *Pinus sylvestris*" (*B.C.A.*, 1929, B, 218); E. Knecht and N. B. Maurice on "The Unsaponifiable Constituents of Rosins" (*B.C.A.*, 1926, B, 21); P. A. Bobrov on the "Composition of Resin" (*B.C.A.*, 1927, B, 392); *C.T.J.*, 1930, **87**, 177; Abietic Acid, Resinates, Rosin Oil, Rosin Spirit, and Wood.

Colloidal Resin—See Paper.

Synthetic Resins—Coumarone resin is made by polymerizing indene and coumarone—constituents of that fraction of coal-tar naphtha distilling between 160° and 200° C. After washing with alkali and acid to remove substances containing oxygen and nitrogen, the oil is treated with concentrated sulphuric acid in small amounts, thus bringing about polymerization and some degree of sulphonation, and upon distillation of the oily part of the product the benzols are carried over, leaving the coumarone resinous material ($C_6H_4.CH.O.CH$) in the retort. Alternatively other polymerizing agents, such as compounds of zinc, aluminium, and tin, can be employed.

Of the other various types of so-called ester gums, synthetic resins, or plastics, many are obtained from phenol, cresol, acetone, casein, lignin, furfurol, naphthalene, acrolein, thiourea, phthalic anhydride, etc., by the action of formaldehyde under varying conditions and are generally known as "condensation products." With respect to formaldehyde products, it has been shown that with acetone and its homologues in alkaline media, as the series rises, larger amounts of alkali and more lengthened heating are required. The world's production in 1926 was 13,000 tons, and about 95 per cent. was of the phenol-aldehyde type, such as "Albertol." A classification of these various products is given by R. H. Kienle (*Ind. Eng. Chem.*, 1930, **22**, 590).

The yellowish to red synthetic resins are not soluble in water, but are variously soluble in alcohol, naphtha, ether, turpentine, acetone, benzene, butyl alcohol, cresols, cyclo-hexonal, tetrahydronaphthalene, carbon disulphide, etc., and used in compounding rubber goods, lacquers, paints, inks, insulating and binding materials, domestic ware, adhesives, varnishes, for lining vessels, and as substitutes for shellac.

Synthetic resins include "Albertol," "Acrolite," "Bakelite," "Erinoid," "Beatl," "Durium," "Formite," "Condensite," "Galalith," "Glyptal," "Indurite," "Mouldensite," "Nestorite," "Novolak," "Margalite," "Pollopas," Polyvinyl Resins, "Redmanol," "Resinite," and "Synthite," most or all of which are described under their respective names. Formaldehyde Resins (p. 371).

Further references: Article on synthetic resins ("Glyptal" type in particular), by E. E. Walker in the "Plastics and Allied Industries" number of *The Times* Trade and Engineering Supplement, March 28,

GUMS AND RESINS (*Continued*)—

1931, and summary of it (*C.T.J.*, 1931, **88**, 330); G. T. Morgan on "Formaldehyde Condensations," etc. (*Chem. and Ind.*, 1930, **49**, 394 and 740); L. V. Redman on "Recent Development in Manufacture of Synthetic Resins" (*Chem. and Ind.*, 1931, **50**, 87); C. H. Bryson on "Synthetic Resins in Industry" (*Ind. Chem.*, 1925, i., 10, 73, and 145); T. H. Fairbrother (*Ibid.*, 1927, iii., 34); W. Garner (*Ibid.*, 1927, iii., 341); reference to their value in electrical insulation (*C.T.J.*, 1931, **88**, 512); T. H. Barry on "Coumarine Resins" (*Ind. Chem.*, 1927, iii., 431 and 479, and 1928, iv., 53 and 501); A. A. Drummond on "Formaldehyde-Phenolic Resins" (*C.T.J.*, 1927, **80**, 227); J. E. Driver (*J.S.C.I.*, 1927, **46**, 197 T); Backeland and Binder (*J.S.C.I.*, 1925, **44**, B, 326); *C.T.J.*, 1926, **79**, 562, and 1927, **80**, 280; and a reference to the acetone condensation products, 1928, **82**, 628; *Chem. and Ind.*, 1927, **46**, 234; H. W. Rowell (*Ibid.*, **46**, 573 and 592); Spencer and Murray (*Ibid.*, **46**, 637; also 1929, **48**, 1158); "Survey," by A. A. Drummond (*Trans. Inst. Rubber Ind.*, 1928, **4**, 40-58); A. V. Mory (*Ind. Eng. Chem.*, 1927, **19**, 1106); W. H. Nuttall (*Chem. and Ind.*, 1931, **50**, 299); H. Stäger (*B.C.A.*, 1931, **50**, 553); reports of two papers by W. C. Smith, and Bevan, Strafford, and Walker (*Chem. and Ind.*, 1931, **50**, 134); Morgan and Megson on "Phenol-Formaldehyde Resins from Low-Temperature Tar" (*J.S.C.I.*, 1931, **50**, 191 T); Bevan and Siddle on "Synthetic Resins, with Special Reference to Paint and Varnish Industries" (*Chem. and Ind.*, 1932, **51**, 251); *The Chemistry of the Natural and Synthetic Resins,* by T. H. Barry (with others) (Ernest Benn, Ltd.); and *Artificial Resins,* by Scheiber and Sändig (Sir Isaac Pitman and Sons, Ltd.); Balsams, Formaldehyde, and Vinyl Alcohol.

GUN-COTTON—See p. 330, Collodion Cotton, Explosives, Nitro-cellulose, and Pyroxylin.

GUN-METAL—An alloy of 9 parts copper with 1 part tin.

GUNPOWDER—See Explosives.

GUTTA-PERCHA—The natural, dark, hardened juice of the Sapotacea or gutta-percha trees (*Isonarda percha* or *Isonarda gutta*) which grow in equatorial regions (Borneo, Brazil, Malay, Singapore, Ceylon, etc.). It exudes from incisions made in the bark, and in a pure state is white, insoluble in alcohol, but soluble in carbon disulphide, carbon tetrachloride and chloroform, turpentine being a partial solvent. It is obtained from the leaves, which contain about 2·3 per cent., the twigs (0·7 per cent.), and the bark (1·2 per cent.), by heating in hot water or steaming up to about 70° C., the gutta being skimmed off the surface and subsequently washed in hot water. As thus obtained, it contains associated resins, which have to be removed by suitable solvents such as petroleum spirit. The separation of the resins and their industrial applications is the subject of an article by F. Harriss Cotton (*India-Rubber Journal,* October 12, 1929), reproduced in *C.T.J.*, 1929, **85**, 466). The de-resinified product is very prone to oxidation, becomes

GUTTA-PERCHA (*Continued*)—

soft and impressionable when warmed in hot water at 37° C.; exhibits a dielectric constant 2·56, melts at from 120° to 130° C.; is largely used as an insulating material for cables and electric wires, also as a covering for golf-balls, for making belting, carboys, bottles, funnels, jugs, taps, valves, etc., in dentistry and waterproofing. When vulcanized, it does not become plastic upon warming and assumes characters resembling those of vulcanized rubber. Gutta-percha is a hydrocarbon ($C_{10}H_{16}$), having near chemical relationship to turpentine, and isomeric with the hydrocarbon of caoutchouc rubber. (See A. W. K. De Jong (*B.C.A.*, 1930, B, 1039) and Rubber.)

GYPSUM—See Calcium compounds.

H. ACID—See Acid H.

HABER PROCESS—See Nitrogen Fixation (p. 620).

HÆMATINE (HÆMINE)—The red colouring matter of the blood is hæmoglobin (chromo-protein), a body of very complicated constitution, consisting of hæmatine and albuminous matter, which, when dissociated, yields hæmatine of the composition $C_{32}H_{32}Fe_2N_4O_5$ or $C_{34}H_{34}FeN_4O_6$, and chemically related to chlorophyll. It is stated that hæmoglobin exists in the blood as the sodium or potassium salt. (See Thudichum and Kingzett (*J.C.S.*, 1876, ii., 255; *Chem. Soc.* Annual Reports, xxiii., 249); also Chlorophyll and Respiration.)

HÆMATITE (Hematite)—Iron ore of many varieties. (See Iron.)

HÆMOGLOBIN—See Hæmatine.

HAFNIUM—The name given to a recently discovered elemental matter of atomic number 72, described as a zirconium homologue, detected by X-ray spectroscopy; apparently present in zirconium minerals to the extent of about 1 per cent., and rarely more than 2 per cent., the richest being *alvite, cyrtolith, nargecte,* and *malakon*. An atomic weight of 178·6 has been provisionally assigned to it, and it appears to be the same substance as so-named celtium.

It is reported that the oxide as derived from the nitrate by reduction with hydrogen in association with tungsten oxide (to the extent of between 0·1 and 3 per cent.) gives to the metallic tungsten subsequently obtained by sintering the mixture in hydrogen, the property of being easily drawn. For some further particulars concerning hafnium, see van Arkel and De Boer (*J.S.C.I.*, 1925, **44**, 994); *Analyst,* 1927, **52,** 287; and *C.T.J.*, 1925, **77**, 748; see also Zircons.

"HAILCRIS"—A British white glass for making miners' lamps, water-tight fittings, lamp globes, etc.

"HAILUXO" GLASS—A British make claimed to be equal to the best Jena glass; used for making miners' glasses and chemical apparatus of high heat-resisting quality.

HAIR—Consists of coalesced horny cells of gelatinous character containing from 0·75 to 2 per cent. of mineral salts. (See "Hairs and Fibres," by C. A. Mitchell (*Chem. and Ind.*, 1930, **49**, 451); *A Study of Hairs and Wools,* by J. Glaister (Cairo: Univ. Press, 1931); also Fibres.)

HAIR HYGROGRAPH—See Hygrograph.

HAIR SALT—See Aluminium (Sulphate).

"HALARSOL"—A stabilized solution of 3-amino-4-hydroxy-phenylarsenoxide, being a new remedy for syphilis and the disease known as yaws.

HALDANE APPARATUS—Designed for air analysis and determining methane and carbon monoxide contents of mine gases, etc. A modified apparatus is described by L. C. McNair (*J.S.C.I.*, 1929, **48,** 374 T).

HALFA (HALVA)—See Esparto Grass.

HALIDES—Metallic and non-metallic binary combinations of the halogens, such as sodium chloride (NaCl) and silicon tetrachloride ($SiCl_4$).

HALL-MARKING—See *Law and Practice of Hall-Marking Gold and Silver Ware,* by J. P. de Castro (Crosby Lockwood and Son, London).

HALOGENATION—The introduction of a halogen into a compound in substitution of hydrogen or hydroxyl, or by addition.

HALOGEN DERIVATIVES of organic bodies are formed by the replacement, for example, of hydroxyl (HO) by a halogen; thus ethyl alcohol by the action of hydrobromic acid is converted into ethyl bromide: $C_2H_5OH + HBr = C_2H_5Br + H_2O$.

HALOGENS—See Elements (p. 301).

HALOIDS—Salts composed of halogen elements with metals, such as sodium chloride and potassium iodide.

"HAMMOND" BURNER—In this burner (giving a calculated flame temperature of 2,145°) the air and fuel are well diffused together in a mixing head, the components being divided into a great number of impinging streams. (See papers by C. F. Hammond, *Chem. and Ind.*, 1930, **49,** 165, and 1931, **50,** 733; *J. Inst. Fuel,* 1930, **3,** 303; *C.T.J.*, 1931, **88,** 302; *Trans. Inst. Chem. Eng.*, vol. 9, March, 1931; Linseed Oil (p. 545), Steam (p. 857), and Submerged Combustion.)

"HAMONITE"—An activated carbon made from peat.

HANKOW WOOD OIL—See Tung Oil.

HANUS REAGENT—Ten grms. iodine monobromide in 500 c.c. glacial acetic acid, used for determining iodine values, and preferred in some cases to Hübl's reagent. (See Fats, p. 337.)

HARDNESS—See Desch's address on "The Nature of Hardness" (*Chem. and Ind.*, 1929, **48,** 487); and D. A. N. Sandifer on "The Pendulum Hardness Tests of Commercially Pure Metals" (*B.C.A.*, 1930, B, 1074); Linseed Oil (p. 545), Brinell Ball Test, and Metals.

HARTSHORN—An old name for crude ammonium carbonate as originally obtained by distillation of horn shavings.

HASHIS—See Hempseed Oil and Gums and Resins (Cannabis Indica).

HATCHETTINE (Hatchettite)—A mineral of tallow-like and hydrocarbon character resembling ozokerite, found in some coal-beds and bogs; m.p. 115° to 170° F.

HAUSMANNITE (Mn_3O_4)—A mineral of crystal system, No. 2, and sp. gr. 4·72. (See Manganese Oxides.)

"HAVEG"—A material of sp. gr. about 1·6 used for construction of chemical plant, made of "bakelite" with a filling of asbestos of high silica content. (See "Bakelite.")

HAZEL-NUT OIL is reported to have a sp. gr. of about 0·9152 to 0·9156, sap. v. about 190, i.v. (Hanus) 84 to 85, and to be devoid of arachidic acid. The hazel (*Corylus*) is a genus of the N.O. Cupuliferæ, the common hazel being *C. Avellana*.

HEAT—The view taken by Sir Isaac Newton concerning the nature of heat is that it has its origin in the internal motions of the particles of bodies—that is to say, movements or vibrations caused by the exercise of energy; but, according to the theory of relativity, heat in common with light is electro-magnetic and material in character.

The sun is the chief source of light and heat, both of which constitute parts of the total energy derived from that source. Heat can be produced by friction or exercise of power, as rendered evident in the use of machinery, when the parts of metal rubbing against each other become very hot. An indefinitely large amount of heat can be generated by subjecting a mass of brass to friction, as illustrated by the great heat that is produced in the boring of metals, and it may be stated that, when two pieces of ice are rubbed together, sufficient heat is produced to melt the ice.

The British thermal unit (B.Th.U.) is that required to raise 1 lb. of water at its temperature of maximum density, 1° F. = 250 gramme-calories, the gramme-calorie being the amount of heat required to raise 1 gramme of water through 1° C. One (1) calorie = 0·00396 B.Th.U. and 4·183 joules.

The heat value of one therm of gas is 100,000 B.Th.U.s, and that of one Board of Trade unit of electricity is 3,411 B.Th.U.s.

Many chemical dissociations and interactions can be effected by the agency of heat, and in all chemical interactions heat is either given out or disappears. When quicklime is mixed with water (slaked) it combines therewith, forming a hydroxide, and considerable heat is developed, as evidenced by the generation of steam. In most cases there is an evolution of heat, but in others it is necessary to apply heat to bring about the desired chemical change. (See Dissociation.)

Compounds—hydrochloric acid, for example—in the formation of which heat is developed are termed *exothermic*, and those—carbon disulphide, for example—in which heat disappears are styled *endothermic* in character. This heat is named *the heat of formation*, that developed in the formation of hydrochloric acid by the equation $H_2 + Cl_2 = 2HCl$, for instance, being accompanied by the production of 44,000 calories or thermal units, and is expressive of the difference between the energy of the constituent elements and the compound. (See Entropy.)

The so-called "heat of solution" is referred to under the heading of Solution and Solvent Action.

HEAT (*Continued*)—

According to the law of Hess, the energy change involved in any chemical reaction is constant, and independent of the stages by which the final result is reached. If, therefore, for example, by the oxidation to carbon dioxide of 12 grammes of carbon (of atomic weight 12) 94,300 calories are evolved, while 28 grammes of carbon monoxide (CO of molecular weight 28), burning into dioxide, yields 68,100 calories, the difference—viz., 26,200—is that of the heat of formation of carbon monoxide. Devices for determining the heat generated by burning substances or by chemical interactions are named calorimeters. These instruments are used also for the determination of specific heats and the calorific values of substances. (See Calorimeters.)

The heat of the human body is produced by the chemical changes that are always going on in it during life.

Light can be changed into heat, and electricity can also be converted into heat and light, as evidenced by the ordinary electric lamps, which evolve both light and heat. According to prevalent ideas, an electric current produces heat in a conductor because the drift energy of the electrons is to some extent converted into irregular motion energy by their collision with the atoms of the conductor. The same change is utilized in a larger degree in the construction of electric radiators (for warming) and electrical furnaces.

When solid, liquid, or gaseous substances are heated, they for the most part enlarge or expand, and when cooled they contract.* The wheelwright makes use of this knowledge in affixing iron tyres when in a very heated condition to wheels, so that upon cooling they clamp by contraction and hold tight to the wooden rims. On the other hand, some metals and alloys expand at the moment of setting, and thus give a sharp casting, whereas others contract at the moment of setting, and in consequence give a bad casting.

Many solid substances, such as sulphur, camphor, naphthalene, and iodine, can be *sublimated* by heat—that is to say, they can be converted into the state of vapour, and when the vapour is cooled, the substance is redeposited in the solid form—a sort of dry distillation.

Again, many liquid bodies, such as water, can be *distilled*—*i.e.*, boiled and thereby converted into vapour, and when the vapours are cooled again, they condense once more into the original liquid forms. Ether, alcohol, turpentine, and many other liquids, can be distilled in this way, and the process is often used for purifying substances from associated impurities. (See Distillation.)

The highest temperature at which any liquid can be converted into vapour at the standard pressure of 760 mm. of mercury is known as its boiling-point—that is, the temperature at which its vapour pressure is

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* Ice may be very much colder than the surrounding water, although it floats. Water has a maximum density at 4° C., but if cooled below or heated above this temperature it expands; but for this, in case of great cold, our lakes and rivers might become frozen solid to the bottom. If water had not this peculiar property, our climate would be of arctic character and a large part of the world would be uninhabitable.

HEAT (*Continued*)—

equal to the atmospheric pressure. In other words, the boiling-point of a liquid is that at which under a given pressure it co-exists with its vapour, the standard atmospheric pressure being generally observed. It is raised in proportion to the increase and lowered in proportion to the decrease of pressure.

By dissolving molecular amounts of different substances in the same weight of the same solvent there is experienced a uniform depression of the freezing-point (Raoult's law), and the elevation of the boiling-point and the depression of the freezing-point are directly proportional to the lowering of vapour pressure.

The boiling-point is raised by lowering the vapour pressure of a liquid due to the presence of another substance, and an application of this principle is made in the use of a saturated aqueous solution of calcium chloride, by which a bath temperature of 180° C. can be attained.

H. B. Dixon in 1880 demonstrated the fact that perfectly dry carbon monoxide admixed with oxygen could be subjected to sparks from a Ruhmkorff's coil without exploding, but upon admission of moisture and resparking, explosion instantly followed. Baker has shown that carbon, sulphur, and phosphorus, when carefully dried, will not burn in oxygen at the temperatures at which they ordinarily ignite; also that drying has a marked influence in raising the boiling-points of many fluids and the melting-points of certain solids. For example, after drying them by sealing up with phosphorus pentoxide for long periods, many liquids show a large rise, the boiling-point of bromine rising from 63° to 118° C.; that of ether rising from 34·9° to 83° C.; that of mercury from 357·33° to 420° to 425° C.; that of benzene from 80·3° to well over 100° C.; that of methyl alcohol from 66° to above 120° C., and so on. Sulphur trioxide dried for one month over phosphorus pentoxide has a melting-point of 50°, while that dried for several years melts at 61°. The suggested explanation is that in the complete absence of water vapour, polymerization or increased molecular complexity takes place in the substances so tested, but the subject is one of considerable controversy. On the other hand, it has been found that benzene and carbon tetrachloride sealed up in glass tubes with phosphoric oxide for about four years did not exhibit any abnormal rise in the b.p.s (Lenher and Daniels, *Proc. Nat. Acad. Sci.*, 1928, **14**, 606); see also J. J. Manley on "The Dehydration of Benzene" (*Nature*, 1929, **123**, 907); J. W. Smith (*B.C.A.*, 1929, A, 1226); S. Lenher (*B.C.A.*, 1929, A, 1371 and 1372); C. J. Brockman (*Chem. and Ind*, 1925, **44**, 501); Andreas Smits (*J.C.S.*, 1928, p. 2399); Briscoe and others (*J.C.S.*, 1929, p. 368); J. W. Smith (*J.C.S.*, 1929, p. 788); S. Lenher (*Nature*, 1929, **123**, 907); H. B. Baker's address on "Molecular Association" (*J.C.S.*, April, 1927); "Notes on Manipulation in Intensive Drying," by H. B. Baker (*J.C.S.*, 1929, p. 1661); W. A. Bone (*J.C.S.*, 1929, p. 1664); "The Influence of Intensive Drying on Inner Equilibria," by Smits, Swart, and Bruin (*J.C.S.*, 1929, p. 2712); and "Intensive Drying," by Miss Greer (*J. Amer. Chem. Soc.*, 1930, **52**, 4191).

HEAT (*Continued*)—

Ether ordinarily boils at 34·9° C., alcohol at 78·4° C., water at 100° C., turpentine at 160° C., and mercury at about 350° C.

The temperatures at which solid or metallic bodies melt are known respectively as their melting or fusing points.

SOME NOTABLE TEMPERATURES

	Centigrade.
Theoretical zero of temperature	−273°
Mercury freezing-point	−38·8°
Freezing-point of water	0°
Mean atmospheric temperature	15·5°
Blood heat	36·9°
Boiling-point of water	100°
Melting-point of tin	232°
Melting-point of lead	327·4°
Mercury boiling-point	350°
Pyrites burners	400°-500°
Melting-point of zinc	419·4°
Red heat just visible in the dark	526°
Melting-point of aluminium	658°
Gas producers	900°-1,300°
Reverberatory furnaces	900°-1,400°
Kilns (for various burnings)	900°-1,600°
Melting-point of silver	960·5°
Melting-point of gold	1,063°
Melting-point of copper	1,083°
Coke ovens (chambers)	1,100°
Deep orange heat	1,100°
Steel melting-point	1,350°
Glass-furnace heat	1,375°
Frit kilns	1,100°-1,400°
White heat	1,500°
Steel melting (in crucibles)	1,500°
Cast-iron melting-point	1,530°
Open-hearth furnace	1,600°
Blast-furnace heat	1,930°
Oxyhydrogen flame	2,800°
Oxyacetylene flame	3,100°-3,300°
Incandescent lamp	1,800°
Electric furnace	3,600°
Arc lamp	4,000°

Temperatures as measured from the theoretical zero −273° C. are termed absolute temperatures and marked T, so that if t° indicates the Centigrade temperature $T° = 273 + t°$; in other words, the Centigrade absolute is made by adding 273 to the Centigrade reading, and the Fahrenheit absolute by adding 460 to the Fahrenheit reading.

Ordinary temperatures are usually determined in this country according to two scales, but chemists for the most part use what is

HEAT (*Continued*)—

called the Centigrade or C. scale; the other is known as the Fahrenheit or F. In Russia, Italy, and Austria there is still another scale, known as the Réaumur or R., but now practically obsolescent. On the Centigrade scale the freezing-point of water is regarded as zero (0°), and the boiling-point is 100°; whereas on the Fahrenheit scale the freezing-point is 32°, and the boiling-point is 212°. To convert a Centigrade reading into a Fahrenheit reading, multiply by 9, divide by 5, and then add 32. To convert a Fahrenheit reading into a Centigrade reading, subtract 32, multiply by 5, and divide by 9.

In the Réaumur scale, the interval between the freezing and the boiling points of water is divided into 80° instead of 100°, as in the Centigrade scale, so that in this case, while the freezing-point is 0°, the boiling-point of water is 80°. To convert Centigrade readings into Réaumur readings, multiply by 4, and divide by 5; and to convert Fahrenheit readings into Réaumur readings, subtract 32, multiply by 4, and divide by 9. (See also Pyrometers and Thermometers.)

High-temperature heating used in respect of such articles as oils, resins, bitumen, varnishes, etc., is realized by the use of super-heated steam, or water heated to a high temperature under pressure, but preferably by the "Merrill" or other process of circulating oil at a low pressure and a high temperature.

Heat transmission for high temperatures required for certain industrial purposes is realized by the use of oil in pipes, 1 lb. of which in cooling from 600° to 500° F. is stated to give up about 57 B.Th.U., or rather more than from the same weight of superheated steam. In other words, it can be made to carry about 128 times as much heat as an equal volume of superheated steam. Its heating and circulation at high temperature (316° C.) calls for the use of carefully designed plant of robust construction and rapid circulation of the oil to avoid local overheating and carbonization. With respect to fluid heat transmission and transference, see J. A. Reavell (*J.S.C.I.*, 1926, **45**, 367 T, and *Trans. Inst. Chem. Engineers*, 1928, vol. 6, p. 115); *B.C.A.*, 1929, B, 1000; *Ind. Chem.*, 1930, vi., 36; A. B. McKechnie (*B.C.A.*, 1929, B, 541); S. J. Kohli (*C.T.J.*, 1930, **87**, 384); heat transmission through building materials: technical paper No. 6, on "Thermal Conductivities, etc." (H.M. Stationery Office); "The Frederking System of Heating Chemical Plant by Use of Imbedded Cells" (*C.T.J.*, 1926, **78**, 350); "Heat Insulation," by J. S. F. Gard (*J.S.C.I.*, 1927, **46**, 101 T); "Heat Insulators," by E. Griffiths (*B.C.A.*, 1929, B, 913); "The Insulation of Heated and Cooled Surfaces," by Gard and Robinson (*J.S.C.I.*, 1930, **49**, 125 T); "Exchange of Heat: Heaters and Coolers," by C. H. Butcher (*Ind. Chem.*, 1930, vi., 404); *Ind. Chem.*, 1929, v., 332); "Heat Exchange in Modern Industrial Practice," by Basil Heastie (*Ind. Chem.*, 1931, vii., 438, and 1932, viii., 87); an article on temperature regulation in respect of food factories and a description of the "Area" regulator (*Ind. Chem.*, 1925, i., 345); description of a thermo regulator (*Ibid.*, 1929, v., 256), and that of the Drayton V.T. Regulator (*Ibid.*, 1931, **50**, 852).

HEAT (*Continued*)—

The Cambridge Instrument Company, in List No. 150, describes various appliances to control any temperatures between −200° and +1,700° C., the control being either electric or mechanical. See also J. B. Hinchley on "The Measurement of Temperature in Technical Practice" (*Chem. and Ind.*, 1926, **45**, 976); H. M. Brown on "Methods of Measuring Temperatures" (*Ind. Chem.*, 1926, ii., 166); S. T. Bowden on "A Constant Temperature Preheater" (*J.S.C.I.*, 1930, **49**, 257 T); particulars of the International Temperature Scale in the Report of the National Physical Laboratory, 1928 (*Analyst*, 1929, **54**, 292); book by Ezer Griffiths (C. Griffin and Co., Ltd., London); also Clays, Refrigeration, Thermotyme, Thermometers, and Thermostat.

A flame of above 3,000° C. is stated to be obtained by the use of liquid fuel led by a tube from the container to a special burner, by which it is atomized and forced out in a horizontal cone by a stream of hydrogen, the combustion being intensified by a mantle of oxygen enveloping the cone from the outer part of the burner. Carbon from camphor and wood charcoal are stated to be converted into graphite by this flame, and refractory substances like tungsten and molybdenum are easily fused, so that it would appear to rival the electric furnace.

By evaporating liquid hydrogen under reduced pressure, Dewar reached to a temperature 260° C. below freezing-point—that is, only 13° C. above absolute zero. The lower temperature of −271·5° C., or only 1·5° above absolute zero, was later brought about by the evaporation of liquid helium under very low pressure, and it is reported that W. H. Keesom, of Leyden University, has since succeeded in reaching and maintaining a temperature of 0·82 of a degree above absolute zero throughout a space of 200 c.c.

A substance is said to be a good *conductor* when heat is easily transmitted by or through it; thus, if one end of a copper or iron wire be held by the hand and the other end placed in the flame of a lamp or candle, the heat is quickly conducted from that end to the one held in the hand, and can be felt. The metals as a class are good conductors.

A slab of marble or metal feels colder to the hand than a block of wood, because those substances are better conductors of heat and more quickly take heat away from the hand. Charcoal is an instance of a bad conductor, so that a short stick of it can be made red-hot at one end and held by the hand at the other without feeling any sensation. Air also is a bad conductor, as are, indeed, all gases.

Heat may flow either by conduction, radiation, or convection, convection being the movement of heated matter as used in fluid-heating operations by steam, water, or hot air.

When water is sufficiently heated in a closed vessel—that is to say, in such a way that the vapour or steam cannot escape—the temperature of the water goes beyond its ordinary boiling-point, and the steam is held under pressure, the boiling-point of the water increasing with the pressure. Of course, this can only be done in very strong vessels; otherwise they would explode with violence. When water is heated in this way to a temperature of 121° C.—that is, 21° C. above its ordinary

HEAT (*Continued*)—

boiling-point—the pressure of the steam generated is equal to 30 pounds on the square inch (=to 2 atmospheres of 30-inch mercury), and the construction of steam engines is based upon a knowledge of these facts. Steam under pressure, as generated in locomotives, is used to force down a piston in a cylinder, and this movement is made to co-operate with the connected wheels in such a way as to bring and maintain a train in motion.

The great heat generated by the burning fuel used under the boiler is taken up by the water and converted into force—that is to say, water which at the ordinary temperature of the air is a quiet, harmless liquid, can, by becoming superheated, assume an energy so great that, unless the boilers were made of intensely strong material, they would explode. Illustrations of the conversion of chemical action into energy are further afforded by the explosion of the mixture of petrol vapour and air as utilized in the engines of motor vehicles, and by the use of explosives. (See Energy, Explosives, and Force.)

The *mechanical equivalent* of heat is expressed by the ascertained fact that a weight of 1 lb. falling through 778 feet may produce, by friction or otherwise, enough heat to raise the temperature of 1 lb. of water 1° F. (See Force (Joule), p. 369.)

When a gas, such as carbon dioxide, is liquefied by cooling and pressure, and then allowed to escape by a jet from its container, some part of the escaping gas will absorb heat from the other part, causing it to be deposited in the solid form, resembling snow. In a similar way, snow when lying on the ground, during a thaw, will, by absorbing heat from its surroundings, cause ice to be produced in its immediate vicinity. (See Refrigeration.)

In passing from the solid to the liquid state, there is what appears to be a disappearance of heat, so that when solid ice liquefies to water, the heat which thus disappears or is rendered *latent* would suffice to raise the same weight of water through 79° C. On the other hand, when water is frozen, this so-called *heat of liquidity* is evolved, and a corresponding evolution of heat takes place when all substances pass from the liquid to the solid form, the amount varying with the particular substances. Thus, when a saturated solution of sodium sulphate is suddenly agitated, it at once crystallizes, and the thermometer will indicate an immediate rise of temperature.

Again, heat is rendered latent when substances pass from the liquid to the gaseous state, as when, for example, water is converted into steam, the latent heat of which is 536 thermal units.

Specific Heats—It is a known fact that equal weights of different substances absorb different quantities of heat through the same range of temperature; water, for example (which exhibits the highest thermal capacity of all known substances), requires thirty times the amount required by the same quantity of mercury to raise it through a given number of degrees. These relative capacities furnish the so-called specific heats of substances, which may be defined as the ratios of their thermal capacities to that of an equal weight of water; thus, the specific

HEAT (*Continued*)—

Element.	Specific Heat.	Atomic Weight taken as	Atomic Heat.
Antimony	0·0495	120·2	5·95
Arsenic	0·083	74·96	6·22
Bismuth	0·0305	208·0	6·34
Cobalt	0·10303	58·97	6·08
Copper	0·09232	63·57	5·81
Gold	0·03035	197·2	5·99
Iron	0·10983	55·84	6·36
Lead	0·0315	207·2	6·52
Lithium	0·94	6·94	6·52
Manganese	0·121	54·93	6·70
Mercury	0·0334	200·6	6·70
Nickel	0·10842	58·68	6·16
Platinum	0·03147	195·2	6·14
Potassium	0·166	39·1	6·51
Silver	0·0559	107·88	6·03
Sodium	0·29	23·0	6·70
Sulphur	0·1712	32·07	5·49
Tellurium	0·0475	127·5	6·06
Tin	0·0559	118·7	6·65
Zinc	0·0939	65·37	6·14

heat of water being taken as the unit, that of mercury is $\frac{1}{30}$, or 0·033. There is a definite relation between the specific heats and the atomic weights of various solid elements, the former being inversely proportional to the numbers known as their atomic weights. This law, known as that of Dulong and Petit, is expressed by stating that the thermal capacities of atoms of the elements in the solid state are equal, and the table given above briefly illustrates this relationship. Atomic heats are represented by multiplying the specific heats by the atomic weights, and the molecular heat of a compound is the sum of the atomic heats of its constituent elements. (See Flame and Therm.)

HEATING—See Heat.

HEAT INSULATION—See E. Griffiths (*Ind. Chem.*, 1932, viii., 108), Heat (p. 438), and Refrigeration.

HEAT PUMP—See Evaporation.

HEAVY SPAR (**Barytes**)—Mineral barium sulphate ($BaSO_4$), crystal system, No. 4, and sp. gr. 4·3 to 4·7.

HECTARE—See Weights and Measures.

HEDEOMA OIL—American pennyroyal oil, from *Hedeoma pulegioides*, of sp. gr. 0·930 to 0·940 and opt. rot. +18° to +21°; distinct from European pennyroyal oil. (See Pennyroyal Oil.)

HEDERIN ($C_{42}H_{66}O_{11}$)—A glucoside contained in ivy leaves and seeds (*Hedera helix* of N.O. Araliaceæ), which yields upon hydrolysis an acid named hederagenin, together with *l*-arabinose and rhamnose. (See Jacobs and Fleck (*J. Biol. Chem.*, 1930, **88,** 153).)

HEHNER VALUE—See Fats, p. 338.

HELIOTROPE (**Heliotropium**)—A genus of the N.O. of plants Boragineæ; the flowers of several species are used in perfumery.

HELIOTROPIN (**Piperonal**) ($CH_2O_2 : C_6H_3.CHO$)—Occurs in the oil of the flowers of *Spiræa ulmaria* (Meadow Sweet) of the N.O. Rosaceæ, and is a white, shining, crystalline substance somewhat soluble in alcohol; m.p. 37° C. and b.p. 263° C. at 760 mm. It is used in medicine and perfumery, and mixed with vanillin sold as "white heliotrope." It is prepared from piperine by saponifying it with potash and oxidation of the potassium piperate by the slow addition of potassium permanganate solution, followed by distillation. (See J. McLang (*C.T.J.*, 1926, **79,** 359), Camphor Wood Oil, and Safrol.)

HELIUM (He)—Atomic weight, 4·002; m.p. below $-271°$ C. A colourless gas of light character (density 2), ranking next to hydrogen in this respect; previously known as a constituent of the sun's atmosphere, but much more recently recognized as present in the air in extremely minute quantity (1 to 2 volumes in 1,000,000) and in certain mineral spring waters, notably those of Bath. It is also found in association with a large number of mineral compounds of uranium, thorium, and other rare earths, including *cleveite, bröggerite,* and *uraninite* (*pitch-blende*), and can be obtained from monazite sand, as also from the helium-neon mixture which results as a by-product of the Linde Oxygen Works. The helium content of Travancore monazite sand is of the order of 1 c.c. per grm. The helium contents of some Japanese minerals have been determined by J. Sasaki (*B.C.A.*, 1930, A, 1156). In common with the other members of the argon group, it is very inert and practically devoid of chemical characters, although there is some evidence that under certain conditions a helide of the probable composition HgHE is formed. (See J. J. Manley, *C.T.J.*, 1926, **79,** 227.) Glass is said to be appreciably permeable to helium, while palladium is almost completely impermeable (Paneth and Peters, *B.C.A.*, 1929, A, 25).

Certain wells of natural gas in many parts of the world contain small proportions of helium; the gas in certain Ontario fields contains from 0·38 to 0·50 per cent.; some in Kansas from 0·5 to 2 per cent., and others in Colorado and Texas from 1 to 8 per cent. From such sources it is produced in large quantities to fill airships, having the advantages over hydrogen that it diffuses more slowly, is non-inflammable and non-explosive in admixture with air, although much more costly, and exhibits only 92 per cent. of the lifting power of hydrogen. According to Snyder and Bottoms (*B.C.A.*, 1931, **50,** B, 110) its thermal conductivity is nearly six times that of air and for airship work its greater density than hydrogen is set off by the diffusion of the last-named gas

HELIUM (*Continued*)—

being 50 per cent. more rapid, etc. It also promises to be of value in replacing the nitrogen of air used by divers.

There is a natural gas-supply at Alberta, Hamilton, Ontario, from which it has been found practicable to isolate helium of 97 per cent. purity on a commercial scale at a cost of less than 2½d. per cubic foot. The gas is stated to be now obtainable in one direct operation, whereas in the older process the natural gas was liquefied and the methane content boiled off first of all, then the other constituents, the helium with its low liquefying-point remaining to the last.

R. Taylor has shown that helium can be liberated from monazite sand by simply heating at 1,000° C. in a stream of carbon dioxide, experiments having yielded 0·63 c.c./g. at 800° C. and 0·68 at 900° C., the gas showing a composition of He 34·5 per cent., H_2 30·3 per cent., CO_2 24·3 per cent., CO 9·1 per cent., and hydrocarbons 1·7 per cent. The crude gas can be purified by passage over heated copper oxide to remove the hydrogen and carbon oxides, and then passed over metallic magnesium heated to 600° C. to free it from nitrogen, and finally over metallic calcium at 560° C., thus yielding helium of 99·5 per cent. purity. (See R. Taylor (*J.S.C.I.*, 1929, **48**, 369 T) and G. T. Morgan (*Chem. and Ind.*, 1930, **49**, 742).)

Helium liquefies at −268° C., and by subjecting the liquid to a pressure of 128 atmospheres and a temperature of 4¼° absolute, Keesom (of Leyden) succeeded in solidifying helium. (See W. H. Keesom (*B.C.A.*, 1926, A, 893); *Chem. and Ind.*, 1926, **45**, 777; and E. Cohen (*J.C.S.*, 1927, p. 1203).) One factory in the U.S.A. is reported to be producing helium from natural gases to the extent of 20,000,000 cb. ft. per annum at a cost of £5 per 1,000 cb. ft. An account of the helium industry is given by H. M. Langton (*Chem. and Ind.*, 1931, **50**, 472).

According to a present view, helium is not an ultimate unit in the structure of nuclei, but is a very close combination of four hydrogen nuclei and two electrons, the mass being 4·00 (in terms of $o = 16$)—that is, considerably less than the mass 4·03 of four hydrogen nuclei. Its average density at 0° and 760 mm. at sea-level lat. 45° has been determined as 0·17845. (See *J.C.S. Abs.*, 1925, II., 1045; *Chem. and Ind.*, 1931, **50**, 387; lecture by F. E. Smith (*Inst. Chem.*, December 18, 1931, pp. 13 and 14); also Atoms, Elements, Radio-activity, and Radium.)

HELLEBORE, as obtained from the root of the black variety (*Helleborus niger*, N.O. Ranunculaceæ), contains a nitrogenous, crystalline substance soluble in alcohol, named helleborine. This variety of herb (Christmas rose, *H. niger*) occurs abundantly in the South Alpine woods of southern and eastern Europe. Other varieties are the green hellebore (*H. viridis*) (U.S.A.) and white hellebore (*Veratrum album*, N.O. Melanthaceæ) of central and southern Europe. Pharmaceutical preparations are made from the roots of both the white and green hellebores. (See Delphinin and Veratrum.)

HEMATINE—See Logwood Extract.

HEMATITE (**Hæmatite**)—See Iron.

HEMICELLULOSES—The hemicelluloses have been regarded as the anhydrides of monosaccharoses; insoluble in water and readily hydrolyzed by dilute mineral acids. In a recent report to the Medical Research Council on food values, Dr. McChance groups hemicelluloses as comprising profurfurals (including the pentosans, free pentose sugars, true hemicelluloses and pectins, nucleic acid, and the precursors of methyl furfural), inulin and the fructosans, and other hexosans such as mannans and galactans. (See Hexosans, Pentosans, and Pentoses.)

HEMLOCK (*Conium maculatum*)—A genus of plants (herbs) of the natural order Umbelliferæ, growing in Great Britain and other parts of Europe, Asia, North America, and Chili, containing an active, narcotic, alkaloidal principle known as coniine ($C_8H_{17}N$) or $C_5H_{10}N(C_3H_7)$—a colourless, oily liquid which boils at 167° C., is soluble in alcohol and ether and sparingly soluble in water. It is obtained by distillation of the plant or fruit with a solution of sodium carbonate and is used in medicine.

An artificial product of the same composition has been synthesized, but it is optically inactive, whereas the natural product is lævorotatory.

HEMLOCK FIR (*Pinus canadensis*)—This tree forms a great part of the Canadian forests, and the bark is the source of a tanning material; a fragrant oil can also be distilled from the leaves and twigs of sp. gr. 0·913, which is soluble in alcohol, ether, etc., and is used in medicine.

HEMP and HEMPSEED OIL—Hemp is cultivated for its fibre in many parts of Europe and elsewhere, and the seed is extensively used as bird food. The oil is obtained by pressure or extraction from hempseed (*Cannabis sativa*, N.O. Cannabinaceæ), a native of India, and is of faint green colour, non-drying in character, and turns brownish-yellow upon standing. It solidifies at – 27° C., has sp. gr. 0·925 to 0·928, sap. v. about 192·5, i.v. 141 to 148, and ref. ind. 1·448 at 15° C.; is soluble in ether, benzol, and carbon disulphide, and used for illuminating purposes and in making soft soaps, paints, and varnishes.

Many varieties of so-called hemp, such as those from Bombay, Madras, Jubbulpore, and Sann, are stated to be really pseudo-hemps (*Crotalaria juncea*), although it is difficult to distinguish them from genuine hemp, which comes from the cannabis species. Other varieties are the so-called Manilla and Sisal hemps. The ash of the genuine hemp contains about 2 to 6 per cent. ferric oxide, while that of the pseudo varieties contains from 8 to 12 per cent.

"Indian hemp" (Gauza) means the dried flowering or fruiting tops of the pistillatic plant from which the resin has not been extracted.

Korean hemp is stated to contain about 62·42 per cent. cellulose and 30 per cent. oil, and finds application for textile purposes.

Manchurian hemp seed cake is stated to contain nearly 10 per cent. oil, 30·88 per cent. albuminoids, 20·32 per cent. digestible carbohydrates, and to have considerable value as a feeding stuff. The tow is used as a cleaning waste and by upholsterers for stuffing.

HEMP AND HEMPSEED OIL (*Continued*)—

The top leaves and other tender parts of the common hemp (*Indica*) are used in the preparation of the compound known as hashish (hasheesh) used in some eastern countries (Turkey, Arabia, and Egypt) for chewing. The gum-resin is prepared for chewing by boiling with fresh butter, or the leaves, etc., are dried, and then used for smoking or chewing. It has an intoxicating effect. Its active principle has been the subject of study by F. Bergel (*B.C.A.*, 1930, A, 1431); see also Gums and Resins (*Cannabis indica*), Hemp, Manilla, and Sisal Hemp.

HENBANE (from *Hyoscyamus niger*, etc., of the N.O. Solanaceæ)—Poisonous plants containing two alkaloids in the leaves and seeds (to below 0·2 per cent.) named hyoscyamine (white and crystalline, $C_{17}H_{23}NO_3$) and hyoscine (uncrystallizable, $C_{17}H_{21}NO_4$). The plant is stated to grow wild on the north coast of Somerset and throughout Europe (particularly near the Mediterranean coast), parts of Asia and the U.S.A.

Hyoscyamine, together with atropine, also occurs in the leaves and seeds of stramonium (*Datura stramonium*).

Hyoscine is a powerful narcotic, and hyoscyamine exhibits mydriatic action. Wild Manchurian henbane seeds (*ten-sen-si*) also contain hyoscine. (See Atropine and Belladonna.)

HENNA (Al-Kenna)—The root and leaves of *Lawsonia inermis*, otherwise known as Egyptian privet, which grows in North Africa, Arabia, Persia, East Indies, and other warm moist climates. It contains a crystalline orange-yellow colouring matter named *lawsone* in the leaves, of m.p. about 192° C., which is soluble in water and dyes wool and silk. With alkalies it gives a bright orange-red coloration, and has the composition $C_{10}H_6O_3$. It is employed in the East to dye the nails, teeth, hair, and garments.

HEPTANE—See Hydrocarbons.

HEPTOIC ACID (Œnanthic Acid) ($C_7H_{14}O_2$ or $CH_3(CH_2)_5COOH$)—One of the normal fatty acids, m.p. $-10{\cdot}5°$ C., b.p. 224° C., and sp. gr. 0·9212; prepared by the oxidation of heptylic aldehyde. (See Œnanthol.)

HEPTYL—The acylic radical C_7H_{15}.

HEPTYLENE—See Hydrocarbons (Olefines).

HERMETICAL SEAL—The closure of a hollow vessel by melting or cementing the lips of its orifice or opening. Thermometers are hermetically sealed.

HEROIN (Diacetylmorphine) ($C_{17}H_{17}(C_2H_3O_2)_2NO_3$)—A white, crystalline, poisonous substance of m.p. 171° C., soluble in hot alcohol and ether; prepared from morphine by acetylation. Both it and the hydrochloride ($C_{17}H_{17}NO_3(CH_3CO)_2HCl$), a white, crystalline, poisonous salt, are used in medicine.

HERRING OIL—See Fish Oils.

HERTZIAN WAVES—Waves with lengths ranging from some thousands of metres to 1 mm. resulting from oscillations produced by a spark dis-

HERTZIAN WAVES (*Continued*)—
charge between two metal conductors highly charged with positive and negative electricity, thus causing a reverberatory effect. These waves are detectable by means of an appliance known as a "resonator," and are viewed as confirming the electro-magnetic theory of light; they can be reflected, and constitute the germ of "wireless" telephony. (See Southern's *Electricity and the Structure of Matter* (Oxford University Press); also Light and Wave Lengths.)

HESPERIDENE—A terpene constituent of oil of orange. (See Essential Oils and Hydrocarbons (Terpenes).

HESPERIDIN—See Glucosides.

HETEROCYCLIC—A division of organic compounds containing rings or nuclei of hetero-atoms; that is to say, one or more atoms of other elements than carbon in the ring, such as nitrogen, oxygen, or sulphur.

HEXACHLORO-ETHANE—See Perchloro-ethane and Solvents.

HEXAD—See Valencies.

"HEXALIN" (Cyclohexanol)—Prepared from phenol by hydrogenation in presence of nickel at 180° C., and used for diminishing the hydrolysis of soap solutions, etc. (See G. Vavon and A. L. Berton, *J.C.S. Abs.*, 1925, I., 806.) There are several so-called hexalin and methylhexalin soaps on the market named "Savonade," "Texapon," "Texalin," "Hydralin," etc. They are alleged to possess the property of readily dissolving lime and magnesia soaps, to exhibit energetic washing action and excellent solubility, while being also stable to dilute organic acids. (See also "Sextol," "Sextate," "Sextone," and Hydrogenated Phenols.)

HEXAMINE (Urotropine, Hexamethylene Tetramine) ($C_6H_{12}N_4$ or $(CH_2)_6N_4$)—A white, crystalline substance, soluble in water and alcohol, prepared by the action of formaldehyde on ammonia, and used as a biliary antiseptic and internal disinfectant for the urinary system, the acid of the urine converting it into formaldehyde. It was used in masks as an absorbent for phosphene gas in the Great War, and finds some application as a rubber accelerator.

HEXANE—See Hydrocarbons.

HEXOSANS (Hemicelluloses)—Derived from the hexoses having the general formula $(C_6H_{10}O_5)_n$, being condensation products of hexose sugars intermediate between simple sugars and the celluloses.

HEXOSES—A group of carbohydrates, including *a*-dextrose and *a*-fructose, divisible again into other groups, exhibiting variously the characters of aldehydes and ketones.

HEXYLENE—See Hydrocarbons (Olefines).

HEXYL-RESORCINOL—See "Caprokol."

HIBISCUS OIL (*Hibiscus cannabinus* L., a genus of the N.O. Malvaceæ) —The plant which yields this oil (known as the Deccan hemp of western India) is indigenous in Africa and cultivated in Java, yielding a fibre

HIBISCUS OIL (*Continued*)—

like jute. The seeds, known in Nigeria as "rama," contain about 20 per cent. fat, and can be used as cattle food. The sp. gr. of the oil is 0·9091, sap. v. 189·2, and i.v. 89·7; its chemical properties approximate those of ground-nut oil. (See *Bull. Imp. Inst.*, 1930, **28,** 284, or abstract *B.C.A.*, 1931, B, 106.)

HIDE POWER—See Tannins.

HIDES—See Tanning.

HIGH-BOILING TAR ACIDS—See Phenoloids.

HIGH PRESSURE—See Pressure (High).

HIGH TEMPERATURE HEATING—See Heat and Pyrometers.

HIPPURIC ACID (**Benzamino-acetic**) ($C_9H_9NO_3$ or $C_6H_5.CO.NH.CH_2.CO_2H$)—A constituent of the urine of horses, being an amino-derivative of benzoic acid, which last-named substance is converted into hippuric acid in passing through the animal body. It is a white, crystalline body, of m.p. about 190° C.; easily soluble in alcohol and hot water.

"HIRD" DISTILLATION PLANT—See Distillation.

HISTAMINE—See Ergot of Rye.

HISTIDINE—A hydrolytic product derived from proteins from which histamine may be prepared. (See Bourdillon and others, *Proc. Roy. Soc.*, 1930, B, **106,** 388.)

HISTONES—A certain class of proteins precipitable from solution by ammonia.

HISTOZYME (**Aminoacylase**)—A ferment or enzyme occurring in the kidneys of pigs, calves, and horses, and the skeleton muscles of dogs (as also in some other organs), capable of hydrolysing hippuric acid with production of benzoic acid and glycine, etc.

HOFMANN'S REACTION is one for the formation of amines from amides by the use of bromine in alkaline solution, carbon monoxide being eliminated.

HOLLANDS—A gin-like spirit made from grain, rye being favoured.

HOLMIUM (Ho)—Atomic weight, 163·5. A very rare element of the yttrium group occurring in the minerals *thulium, gadolinite, samarskite,* etc. Its compounds are but little known.

HOMATROPINE ($C_{16}H_{21}NO_3$)—A white, crystalline, hygroscopic, poisonous base allied to atropine, which exercises a mydriatic action or power of dilating the pupil of the eye; m.p. 98° C., ref. ind. 1·56 to 1·62; slightly soluble in water, and soluble in alcohol and chloroform.

HOMATROPINE HYDROBROMIDE ($C_{16}H_{21}NO_3Br$)—A white, crystalline salt, of mydriatic power, soluble in water and alcohol; m.p., 213·8° C.

HOMOCYCLIC (**Isocyclic**)—A division of organic compounds containing rings or nuclei, the atoms of which are of the same element; benzene ring, for example.

HOMOGENIZERS—Mills. (See Grinding.)

HOMOLOGUES—Substances having a relative or corresponding position in a series of analogous bodies. For example, the paraffins, the olefines, and the alcohols are three homologous series rising in degrees of the constituent or radical group CH_2. Substances belonging to such series exhibit, more or less, gradations of many properties and boiling-points. (See Alcohols and Hydrocarbons.)

HONEY contains from 61 to 75 per cent. of a glucose named grape sugar (dextrose), less than 1 per cent. sucrose, and is largely used in making foods and preserves. That the ratio of dextrose-lævulose in natural honey lies between 100 : 106 and 120 : 119 has been questioned. (See Nottbohm and Lucius (*B.C.A.*, 1931, B, 651) on the sucrose content of certain honeys; also Nectar.) Honey exhibits diastatic power, and the suggestion has been made that the diastase comes from the flowers visited by the bees. (See Lampitt and others (*Analyst*, 1929, **54**, 381; 1930, **55**, 666) and K. Braunsdorf (*B.C.A.*, 1931, B, 564).) The composition of prickly-pear honey of Queensland has been given as follows: H_2O, 20 per cent.; cane sugar, 0·95 per cent.; invert sugar, 77·70 per cent.; dextrin, 0·23 per cent.; mineral matter, 0·11 per cent.; acidity (as formic acid), 0·14 per cent.; and undetermined matter, 0·87 per cent. (See *Analyst*, 1927, **52**, 32.) The unpleasant taste and burning sensation of Noors honey from some south-eastern parts of South Africa, derived from various species of *Euphorbia*, are attributed to some 0·1 per cent. content of a yellow oil content (*Chem. News*, 1925, cxxx., 310-312). For other papers on honey see *Analyst*, 1932, **57**, 107-108.

HONEY-STONE or MELLITE ($C_{12}Al_2O_{12},18H_2O$)—A soft resin-like mineral consisting of crystallized native aluminium mellitate occurring in lignite found in Thuringia, Bohemia, and Moravia.

HONGAY OIL—From seeds of *Pongamia glabra*; brown and of characteristic odour. Sp. gr. at 15° C., 0·9273 to 0·9385; sap. v., 185·7; i.v. (Winkler), 85·6 to 88·9; contains a number of glycerides, including those of oleic acid 61·30, linolic, 9·72, and palmitic 6·06 per cent. etc.

HONG KONG OIL—See Tung Oil.

HOOF MEAL is a dried ground mixture of hoof and horn.

HOPS—The fruit of the plant (*Humulus lupulus*, of N.O. Cannabinaceæ) contains a yellow, bitter powder named lupulin, of mixed composition, including resinous bodies, a waxy body, alkaloids, and extractive matters, and when distilled with water it yields valerianic acid and a volatile oil. (See Hops (Oil of).) The real bitter principle is said to form about from 8 to 12 per cent. of the powder, of which the fruit contains about 10 per cent., and includes a sesquiterpene named humulene and two crystalline substances named humulon ($C_{21}H_{30}O_5$) and lupulin ($C_{26}H_{38}O_4$) of m.p. 90·5° to 92° C. Lupulin is twice as strong in antiseptic value as humulon (T. K. Walker).

The plant is extensively cultivated in England, Germany, Russia, the U.S.A., etc., and the flowers are used in medicine. Spent hops con-

HOPS (*Continued*)—
stitute a cellulose waste product produced to the extent of some 12,500 tons annually in Great Britain, and H. Langwell and H. Lloyd Hind have suggested its utilization for the production of alcohol, using as the biological factor an organism from horse manure, of a rod-shaped, spore-bearing, anaerobic character, at an optimum working temperature of from 60° to 65° C.; it is otherwise used as hop manure.

The constituents derived from hops largely contribute to head formation and head retention in beers.

Goodwin, Martin, and Salmon have investigated the fungicidal properties of sodium, potassium, calcium, and barium polysulphides against the conidial stage of hop powdery mildew (*J. Agric. Soc.*, 1930, **20,** 489, and Abstract *B.C.A.*, 1930, B, 877). Using soft soap as the emulsifier, certain vegetable oils have proved of considerable fungicidal value with respect to the powdery mildew of the hop (*Sphærotheca humuli*), notably olive, sesame, and cotton-seed oils. (See H. Wieland and E. Martz on the resin acids of hops (*B.C.A.*, 1926, A, 1248); Pyman, (*Chem. and Ind.*, 1928, **47,** 1265); W. Windisch with others (*B.C.A.*, 1929, B, 412); and "Drying of Hops," by A. Burgess (*B.C.A.*, 1927, B, 199).) Hop-drying in kilns of the "Linhart" type is described by A. H. Burgess (*B.C.A.*, 1930, B, 389).

HOPS (OIL OF)—From hop cones, which yield it upon distillation with water up to about 2·25 per cent., being derived from the lupulin or yellow bitter powder content; green in colour, with the odour of thyme, and said to contain myrcene, geraniol, linalool, humulene, linalyl, isononoate, luparone, and luparenol. It is soluble in alcohol and ether, has a sp. gr. 0·840 to 0·880 at 15° C. and ref. ind. 1·477 to 1·490 at 20° C. The flowers yield from 0·3 to about 1·0 per cent. oil. (See A. C. Chapman, *B.C.A.*, 1929, B, 538.)

HOREHOUND—From the dried leaves and tops of *Marrubium vulgare*, N.O. Labiatæ; used in medicine and confectionery.

HORMONES—A class of substances secreted by special (ductless) glands in the living body, and regarded as essentials to good functional activity and perfect nutrition, to the extent of something less than 1 per cent. of the food. One of these substances is named thyroxin, and is secreted by the thyroid gland; adrenalin is secreted by the suprarenal glands; another is secreted by the salivary glands, and choline, which is found in the alimentary and intestinal tracts of animals. It is also reported that a new hormone from the placental gland has been isolated in a crystallized form by J. B. Collip of McGill University. Adrenalin and thyroxin are related to the amino-acids and have both been synthesized. These hormones are not proteins; they are usually soluble in alcohol and ether, and it is surmised that they are probably allied to the Vitamins.

By agency of these hormones the various organs of the body have the power to affect one another. The pituitary, thyroid, and suprarenal glands definitely regulate certain processes, and if the action of a gland be abnormal, some corresponding abnormality results in the body.

HORMONES (*Continued*)—

The pineal gland, which is surmised to have been a third eye in a remote ancestor, has become in man a gland deeply buried in the brain, and is believed to regulate growth. (See Dale, Dudley, Carr, and Jowett (*J.S.C.I.*, 1926, **45**, 235-246 T); F. H. Carr (*J.S.C.I.*, 1927, **46**, 263 T); A. J. Clark (*Chem. and Ind.*, 1930, **49**, 533); and D. L. Thomson (*Chem. and Ind.*, 1931, **50**, 481); Adrenalin, Enzymes, Insulin, Secretin, Thyroxin, and Vitamins.)

HORN-BLENDE (**Uralite, Amphibole**)—A mineral consisting of compound silicates of various metals (magnesium, iron, and calcium) in association (crystal system, No. 5, and sp. gr. 3 to 3·3). The syntagmatitic variety ($H_2Ca_2Mg_4Al_2O_6.O_{24}$) is described by W. Kunitz (*B.C.A.*, 1931, A, 459), and the green variety is formulated $H_2Ca_2Mg_5Si_8O_{24}$. (See Asbestos.)

HORN MERCURY (**Horn Quicksilver**)—See Mercury Compounds.

HORN SILVER (**Cerargyrite, Chlorargyrite**)—Native silver chloride found in some American States (crystal system, No. 1, and sp. gr. 5·5).

HORSEMINT OIL (**Monarda Oil**), sp. gr. 0·92 to 0·94, distilled from the herb *Monarda punctata*; is yellowish-red, of thyme-like odour, said to contain from 50 to 60 per cent. thymol; soluble in alcohol and ether, and used in compounding liniments. (Compare Monardo Oil.)

HORSE-POWER—See Force.

HOT-PATCHING (of refractory materials, such as retorts, kilns, etc.).

HÜBL NUMBER—See Fats (Iodine Number, p. 337).

HUBNERITE—Mineral manganese tungstate ($MnWO_4$) found in certain American States (crystal system, No. 5, and sp. gr. 7·17).

HUMIDITY—See "The Quantitative Humidification of Air," by Vernon and Whitby (*Trans. Faraday Soc.*, No. 121, vol. xxvii., Part 6, June, 1931); Air, Dew-Point, Hygrograph, and Hygrometers.

HUMUS—Decayed vegetable matter, probably formed from lignin in soil, by the various activities of insect life, fungi, and bacteria. J. Stoklasa regards it as a respiratory by-product of micro-organisms (*B.C.A.*, 1930, B, 577). It contains a substance called humic acid, which decomposes into carbon dioxide and water at 80° C. Oxidation of phenols in alkaline solution leads to the formation of substances which exhibit the properties of natural humic acids, one of them having the formula $C_6H_4O_3$. They can also be prepared from furfurol. Humus is supposed under one view to be formed by the oxidation of quinones, which arise in their turn from hexoses by the elimination of water. Another view is that carbohydrates decompose to form a body named hydroxymethyl furfuraldehyde, which then condenses to form humus. The soluble part of humus contains about 50 to 57 per cent. carbon, 35 per cent. oxygen, 3 to 8 per cent. nitrogen, and is constantly undergoing decomposition by action of air, moisture, bacteria, moulds, and enzymes. (See Thiessen and Engelder, *Ind. Eng. Chem.*, 1930, **22**, 1131.)

HYDNOCARPUS OIL (**H. Anthelmintica Oil**)—Is stated to contain the glycerides of chaulmoogric and hydnocarpic acids. Sp. gr. at 30° / 4° C.,

HYDNOCARPUS OIL (*Continued*)—

0·943 to 0·950, m.p. 20·2 to 23·4, and sap. v. 191·4 to 226·5. (See *Analyst*, 1927, **52,** 32, and 1929, **54,** 347.) The *H. Ilicifolia* oil which grows extensively in Siam appears from the Report of the Government Laboratory to be very similar. The dry kernels yielded 36·1 per cent. of crude oil, having acidity (as oleic acid) varying from 0·6 to 21 per cent.; sp. gr. at 30°/4° C., 0·944 to 0·947; sap. v. 203·6 to 213·1; i.v. (Wijs) 89·7; and m.p. 23° to 32·6° C. (See A. Marcan, *Analyst*, 1929, **54,** 475; Georgi and Teik (*B.C.A.*, 1929, B, 784); D. R. Koolhaas on "Oil from *Hydnocarpus heterophylla*" (*B.C.A.*, 1930, B, 292); and Chaulmoogra Oil.)

HYDRARGILLITE ($Al(OH)_3$)—Crystal system, No. 3, and sp. gr. 2·3.

HYDRASTINE ($C_{21}H_{21}O_6N$)—A white, poisonous alkaloid of m.p. 133° C. from the root of *Hydrastis canadensis* ("golden seal"), growing in Canada and eastern part of the U.S.A., which, as also the hydrochloride ($C_{21}H_{21}O_6N,HCl$), is used in medicine. It is chemically allied to narcotine, and by oxidation yields hydrastinine ($C_{11}H_{13}O_3N$), a white crystalline substance, also used in medicine; m.p. 117° C. The rhizome is said to contain berberine. A salt of the base is used in connection with silver nitrate in sensitizing photographic processes. (See Clark and Winter (*B.C.A.*, 1927, A, 504), and Hope, Pyman, Remfry and Robinson on "A Synthesis of Hydrastine," Part I. (*J.C.S.*, 1931, p. 236), who confirm the formula as $C_{21}H_{21}O_6N$.)

HYDRATES—This term is now reserved for compounds containing H_2O, as, for example, $Na_2SO_4,10H_2O$. (See Bases and Hydroxides.)

HYDRAUTOMAT—A particular type of hydro-compressor used in industry for pneumatic tool and other work.

HYDRAZINE (**Diamide**) (N_2H_4 or $NH_2.NH_2$)—A colourless liquid which boils at 113·5° C., made by reduction from nitrosamine, and manufactured by interaction of sodium hypochlorite and ammonia in presence of glue. It is also produced by the electrical degradation of ammonia. (See Koenig and Wagner, *B.C.A.*, 1930, A, 44.) Its thermal decomposition under varying conditions is the subject of a paper by P. J. Askey (*B.C.A.*, 1930, A, 547), who found, amongst other results, that it decomposes on quartz at 270° to 310° C. as follows: $3N_2H_4=4NH_3+N_2$. (See Nitrosamines and Phenyl Hydrazine.)

HYDRAZOIC ACID (hydrogen azide) (HN_3)—A colourless, white, mobile liquid of explosive character, which can be prepared from hydrazine hydrate; also from sodamide and nitrous oxide by acidification of the sodium hydrazoate thus produced ($NH_2Na+N_2O=NaN_3+H_2O$), and distillation. The pure acid boils at 37° C., and is monobasic; it attacks many metals, such as zinc and aluminium, hydrogen and ammonia being evolved. Its vapour is decomposed by ultra-violet radiation from an aluminium spark; hydrogen, nitrogen, and ammonia in the form of ammonium azide being formed (Beckman and Dickinson).

Its salts are known both as hydrazoates and as azides. (See Azides.)

HYDRAZONES—Products of reaction between certain sugars and phenylhydrazine acetate. The hydrazones have the formula $R:N.NH_2$, R being an alkyl or aryl radical, and result from condensation of aldehydes or ketones with hydrazine.

HYDRIDES—A term given to combinations of hydrogen with other elements, such as potassium and sodium hydrides (KH and NaH), lithium hydride (LiH), lead dihydride (Pb_2H_2) (which look like salts rather than metals), arsenic hydride (AsH_3), phosphine (PH_3), silicon hydride (SiH_4), boron hydride ($B_{10}H_{14}$), and others. The same term is given to combinations of hydrogen with alcohol radicals such as ethyl hydride (ethane) (C_2H_6 or C_2H_5H). The halogen acids may also be regarded as hydrides.

Gaseous hydrides of antimony, bismuth, germanium, lead, mercury, tellurium, tin (SnH_4), and zinc are stated to be formed when an electrical discharge is passed through hydrogen under diminished pressure in presence of these metals. Calcium hydride can be produced by the action of hydrogen gas on molten metallic calcium or on calcium chloride at 550° C. and upwards, when hydrochloric acid gas is evolved. Solid hydrides of arsenic and antimony have been described by G. Druce and E. J. Weeks (*J.C.S.*, 1925, xix., 156 and 157, and cxxvii., 1069-1072, and lead dihydride is stated by E. J. Weeks to be formed as a grey deposit when aluminium foil is exposed to a solution of alkali plumbite (*J.C.S.*, 1925, p. 2845).

HYDRIODIC ACID—See Iodine Compounds.

HYDRION (**Hydrogen-ion**)—The positively charged hydrogen atom. (See Hydrogen-ion Determination and Volumetric Analyses.)

HYDRO-EXTRACTORS—See Centrifuges and *C.T.J.*, 1929, **84**, p. 444.

HYDROBROMIC ACID—See Bromine Compounds.

HYDROCARBONS—Combinations of carbon and hydrogen, constituting a large body of organic compounds of great interest and importance. The more important ones may be roughly classified as follows:

(1) The **Paraffins**—A series of homologous, saturated, aliphatic hydrocarbons of the general formula $C_nH_{2n}+2$, incapable of combining further with hydrogen or halogens and comparatively indifferent to chemical action. The lower and best-known members are:

Methane (CH_4);	b. p.	$-160°$ C.	and sp. gr.	0·415 at boiling-point.
Ethane (C_2H_6);	,,	$-93°$ C.	,, ,,	0·446 at 0° C.
Propane (C_3H_8);	,,	$-45°$ C.	,, ,,	0·536 at 0° C.
Butane (C_4H_{10});	,,	$+1°$ C.	,, ,,	0·600 at 0° C.
Pentane (C_5H_{12});	,,	36·3° C.	,, ,,	0·627 at 14° C.
Hexane (C_6H_{14});	,,	69° C.	,, ,,	0·658 at 20° C.
Heptane (C_7H_{16});	,,	98° C.	,, ,,	0·683 at 20° C.
Octane (C_8H_{18});	,,	125·8° C.	,, ,,	0·702 at 20° C.
Nonane (C_9H_{20});	,,	150° C.	,, ,,	0·718 at 20° C.
Decane ($C_{10}H_{22}$);	,,	173° C.	,, ,,	0·730 at 20° C., etc.

HYDROCARBONS (*Continued*)—

These hydrocarbons exhibit a step-by-step rise of CH_2 and a gradual rise in the specific gravities. Methane, ethane, and propane are known to have each one isomeric form, while butane has two, pentane at least three, and hexane five known ones, while most of the higher paraffins are known in various forms. The isomeric heptanes have been recently prepared in considerable quantities and studied by Marker, Edgar, and Calingaert (*B.C.A.*, 1929, A, 789). (See also S. Young (*Proc. Roy. Irish Acad.*, 1928, **38,** B, 65) on "Boiling-Points of the Normal Paraffins," and Hague and Wheeler on "The Mechanism of Thermal Decomposition of Normal Paraffins" (*B.C.A.*, 1929, B, 536).)

Methane is a colourless, odourless gas known as a constituent of "marsh gas" and "fire-damp," and often results from the decomposition of organic matter under water in marshes and stagnant pools. It burns with a faintly luminous flame, forms an explosive mixture with air or oxygen, its ignition in admixture with air being to some extent dependent upon the nature of the igniting source. As generated from decaying vegetable matters and by the intensive fermentation process of sewage treatment (due to the bacterial fermentation of cellulose) it has been utilized as a motive power in connection with gas plant. It is also used in the production of pure nitrogen.

Supplies of the natural gas of approximately 97·19 per cent. purity are now produced in a Welsh mine, and there is a natural gas from Tariki, Taranaki, consisting of almost pure methane.

It can be liquefied at $-164°$ C. and has recently been solidified at $-186°$ C. It is produced when a mixture of carbon monoxide and hydrogen is passed over nickel at 220° to 280° C. ($2CO + 2H_2 = CO_2 + CH_4$ and $CO + 3H_2 = CH_4 + H_2O$); also when a mixture of carbon dioxide and hydrogen is passed over nickel deposited on magnesia at 328° C. ($CO_2 + 4H_2 = CH_4 + 2H_2O$); or nickel carbide ($Ni_3C$) can alternatively be used as the catalyst. (See Bahr and Bahr (*B.C.A.*, 1929, A, 169); Pascall and Rotalfsen (*B.C.A.*, 1930, A, 1157); "The Influence of Various Catalysts in promoting the Oxidation of Methane by Means of Copper Oxide," by Campbell and Gray (*J.S.C.I.*, 1930, **49,** 447 T); results obtained using a sugar charcoal-nickel catalyst, described by K. M. Chakravarty and J. C. Ghosh (*J.S.C.I.*, 1925, B, 948); the adsorption of methane on charcoal at various temperatures as measured by Frolich and White (*Ind. Eng. Chem.*, 1930, **22,** 1058).)

According to another account, ruthenium oxide is the best catalyst, and quantitative results, it is stated, can be obtained at 250° C. by the use of cobalt oxide to which 15 per cent. alumina has been added. Coal gas contains from 35 to 40 per cent. methane. It is stated that methane can be almost completely converted into acetylene in the arc-oven, while acetylene admits of polymerization to a tarry body about half of which consists of benzene. (Compare C. Fujio, *B.C.A.*, 1930, A, 1399. See also Wheeler and Wood concerning "Recent Experiments on the Pyrolysis of Methane" (*B.C.A.*, 1931, B, 193); Randall and Gerard (*B.C.A.*, 1929, B, 82) on the equilibrium constants of the

HYDROCARBONS (*Continued*)—

process using $CO_2 + 4H_2 = CH_4 + 2H_2O$ (gas), and nickel as the catalyst; C. C. Minter on "The Equilibrium Combustion of a Mixture of Carbon Monoxide and Hydrogen" (*J.S.C.I.*, 1929, **48,** 35 T); the propagation of flame in mixtures of methane and air, by W. R. Chapman and R. V. Wheeler (*J.C.S.*, 1927, p. 38); Holliday and Gooderham on "The Thermal Decomposition of Methane" (*J.C.S.*, 1929, p. 1066, and 1931, p. 1594); two papers by Stanley and Nash on "The Thermal Decomposition of Methane" (*J.S.C.I.*, 1929, **48,** 2 T); "The Action of Spark Discharge on Methane" (*Ibid.*, 1929, **48,** 238 T); Formaldehyde, Marsh Gas, Nitrogen, Sewage, and Water Gas.)

The explosion wave for methane and oxygen has a velocity of 2,322 metres per second.

Ethane is a gas contained in crude petroleum, and can be prepared by the electrolysis of acetic acid and otherwise. Like methane, it burns with a slightly luminous flame. It decomposes at 550° C., the chief products being methane and ethylene.

Propane and **Butane** are also gases, while the next three members of the series are colourless, mobile, inflammable liquids found in paraffin oil as obtained from cannel coal and in petroleum. These hydrocarbons are now prepared from the "wet gas" of natural petroleum wells in the U.S.A. on a large scale, and are variously employed as fuel and for lighting.

Pentane—The ordinary or normal pentane ($CH_3(CH_2)_3CH_3$) is a colourless, mobile, inflammable, pleasant-smelling liquid of sp. gr. 0·6595, b.p. 36·4° C., and m.p. $-130·8°$ C., soluble in alcohol and ether, obtained by fractional distillation from petroleum. It is used in the 10-candle pentane Harcourt lamp, sometimes also as an anæsthetic, and in the manufacture of ice. It is also used in the manufacture of amyl chloride, amyl alcohol, and amyl acetate; the chloride being made by interaction of its hot vapour with chlorine gas, and the chloride in its turn is employed in the manufacture of amyl alcohol. (See Amyl Alcohol, p. 25.) There are two other isomerides of pentane.

Hexane and **Heptane** are colourless inflammable liquids obtained from petroleum by fractional distillation, and used as solvents.

The liquid paraffins are all soluble in alcohol and ether, but not in water. (See Petroleum.)

The homologues from pentane up to those containing 17 carbon atoms inclusive are liquid at 20° C., while the higher members are colourless and solid.

(2) The **Olefines** or **Ethylene** series are a class of unsaturated (acyclic) hydrocarbons of ascending boiling-points and general formula C_nH_{2n} (containing one or more ethylenic double bonds, and named after the corresponding paraffin hydrocarbons by adding "ylene" to the stem or changing the suffix "ane" to "ene"), from which the glycols are derived, including—

HYDROCARBONS (*Continued*)—

Ethylene (C_2H_4)	of boiling-point	−103° C.
Propylene (C_3H_6)	,,	−48° C.
Butylene (C_4H_8)	,,	(See Butylene)
Amylene (C_5H_{10})	,,	+39° C.
Hexylene (C_6H_{12})	,,	68° C.
Heptylene (C_7H_{14})	,,	95° C.
Octylene (C_8H_{16})	,,	124° C.
Nonylene (C_9H_{18})	,,	153° C.
Decylene ($C_{10}H_{20}$)	,,	172° C.; and so on.

Methylene (menthene, CH_2) is not known to exist.

The first three members of the group are colourless gases, and both ethylene and propylene in admixture with oxygen have proved of value as anæsthetics.

When the liquid members are reached (with amylene) they diminish in mobility, while the higher ones, like cerotine ($C_{27}H_{54}$:) and melene ($C_{30}H_{60}$), are solid. These last-named substances can be obtained from china wax and beeswax respectively by distillation. Amylene (pental, trimethylethylene) [$(CH_3)_2CCH.CH_3$], obtained by heating ordinary amyl alcohol with zinc chloride, is a mobile inflammable liquid of b.p. 35° C., sp. gr. 0·666, and disagreeable odour, sometimes used as a local anæsthetic. Several amylene dichlorides are used as solvents.

The olefines readily combine with nascent hydrogen, chlorine, etc., readily polymerize, and are easily attacked by potassium permanganate and chromic anhydride (CrO_3). Most of them are soluble in alcohol and ether, but not in water. The best-known member of the series is ethylene (known also as ethene and olefiant gas), a colourless gas of sp. gr. 0·565, slightly soluble in water and alcohol and known as a constituent of coal and coke-oven gases, from which it can be obtained. It is prepared by the passage of carbon monoxide and hydrogen gases over a catalyst such as finely divided nickel or platinum at 100° C.; also by action of sulphuric acid or syrupy phosphoric acid upon its corresponding alcohol ($C_2H_6O = C_2H_4 + H_2O$). It burns with a luminous flame and is valuable for the preparation of nitro-glycol, also as a constituent of non-freezing nitro-explosives, for the preparation of mustard gas, the synthesis of ethyl alcohol, for preserving fruit, and for turning the green tints of oranges and grape fruit to a yellow or golden colour, for which purpose minute amounts of the very dilute gas suffice.

By combination with chlorine, ethylene forms ethylene dichloride ($C_2H_4Cl_2$), and at low temperatures it reacts with ozone to form an explosive ozonide, which upon treatment with water is hydrolysed as follows: $C_2H_4O_3 + H_2O = 2CH_2O + H_2O_2$.

Butylenes in three isomeric forms are known: α of b.p. −5° C., β of b.p. +10° C., and γ of b.p. − 6° C.; and there are five isomeric amylenes.

See Wheeler and Wood on "The Mechanism of Thermal Decomposition of the Normal Olefines" (*J.C.S.*, 1930, p. 1819).

(3) The **Acetylene** aliphatic series of general formula C_nH_{2n-2},

HYDROCARBONS (*Continued*)—

including acetylene (C_2H_2), contain the trivalent methenyl radical $\vdots CH$ or $H.C\equiv$ and 2 atoms of hydrogen less than the olefines; they are gaseous up to C_4H_6, the intervening ones are liquid, and the highest members are solid. (See Acetylene.)

(4) The **Benzene Hydrocarbons,** of which the best-known members are:

Benzene (C_6H_6), b.p. 80·4° C. and sp. gr. 0·874.
Toluene (C_7H_8), b.p. 110° C. and sp. gr. 0·869.
Xylene (C_8H_{10}), of which there are several modifications. (See Benzene, Toluene, and Xylene.)

(5) A group having a benzene nucleus, including naphthalene ($C_{10}H_8$) and anthracene ($C_{14}H_{10}$); and

(6) The **Terpenes** ($C_{10}H_{16}$)—A series of unsaturated isomeric hydrocarbons of the formula $C_{10}H_{16}$, having boiling-points ranging from 155° to 185° C., all of which are liquid with the exception of camphene. As they exist in essential oils, they are mixtures of terpenes and not chemical individuals, and are often associated with oxidized bodies allied to and, in many cases, derived from them.

Pinene (dextro-pinene) is the chief terpene contained (80 to 85 per cent.) in the American and German turpentine oils; b.p. about 156° C., sp. gr. 0·8587 at 20° C., and ref. ind. 1·465 at 20° C.

Lævo-pinene is the chief constituent of French turpentine, whilst carene, sylvestrene, and hemi-terpene (dipentene) (C_5H_8), together with pinene, are contained in varying proportions in the Russian and Swedish oils.

Indian turpentine contains pinene and two terpenes named *carene* and *longifolene*. Oil of orange contains limonene. Fennel oil and some eucalyptus oils contain phellandrene. (See Owen and Simonsen, *J.C.S.*, 1931, p. 3001.)

Citrene is contained in the oil of citron, hesperidene in the oil of orange, thymene in the oil of thyme, carvene in the oil of cumin, phellandrene in eucalyptus oil and the oil of *Melaleuca acuminata*, etc.

The terpenes form additive compounds, such as the dihydrochlorides, $C_{10}H_{18}Cl_2$; tetrabromides, $C_{10}H_{16}Br_4$; nitroso-chlorides, $C_{10}H_{16}(NOCl)_2$, etc., most of which are well-defined crystalline compounds with definite melting-points.

Kingzett has shown that all the terpenes yield peroxide of hydrogen when oxidized by air, oxygen, or ozone in the presence of water. (See "Sanitas" Fluid and "Sanitas" Oil.)

The associated hydrocarbons of the formula C_5H_8, known as hemiterpenes, include isoprene; those of the formula $C_{15}H_{24}$ are termed "sesquiterpenes," including cadinene, caryophyllene, cedrene, santalene; and diterpenes ($C_{20}H_{32}$), such as carene, among other polyterpenes. (See also Dipentene, Essential Oils, and Isoprene.)

It has been shown that there is a relationship between the sesquiterpenes and some derivatives of naphthalene somewhat similar to that known to exist between the ordinary terpenes and derivatives of ben-

HYDROCARBONS (*Continued*)—

zene. On sulphur dehydrogenation, a number of sesquiterpenes and their alcohols yield one or two derivatives of naphthalene, including "cadalene" ($C_{15}H_{18}$), which is 4:7 dimethyl-1-isopropyl naphthalene.

Isoprene is the best-known hemi-terpene (C_5H_8), whilst dipentene ($C_{10}H_{16}$) is associated with cineol in *Oleum cinæ*, and can be easily prepared from pinene and some other terpenes.

These compounds are further referred to in the descriptions of the various essential oils in which they occur or under their distinct names.

(See Jones (with others) on "Flame Temperatures of Hydrocarbon Gases" (*B.C.A.*, 1931, A, 572), and Dunstan (with others) on "Heat-Treatment of Hydrocarbons" (*J.S.C.I.*, 1931, **50,** 313 T).)

HYDROCHLORIC ACID—See Chlorine.

HYDROCYANIC ACID (HYDROGEN CYANIDE or PRUSSIC ACID) (HCN) is a colourless, volatile gas of b.p. 26° C., solidifying at – 14° C., sp. gr. 0·70, and of peculiar odour like that of bitter almonds. It is the active agent of the killing bottle used by entomologists, an effective vermifuge, and has been used in India for the disinfection of railway carriages and in the U.S.A. for the disinfection of ships. It is being increasingly used as a fumigant for the destruction of insects and vermin pests in or on foods, and its effects on foods therefore call for special attention. It is exceedingly poisonous, and as it is without taste, a person breathing it has little warning until collapse occurs. It is formed by the passage of electric sparks through a mixture of acetylene and nitrogen, and it can also be obtained by distillation from the kernels of bitter almonds or prepared by the action of dilute sulphuric acid upon potassium cyanide (from which mixture the acid can be distilled over with water). As used for fumigating purposes, it is generated by allowing 50 per cent. solutions of sodium cyanide and sulphuric acid to flow and mix together upon a platform within the generator, using a stream of air to convey the gas to the place of application.

Another process is based upon the action of moisture on dry calcium cyanide, the hydrocyanic acid being generated, it is alleged, rapidly and evenly. The calcium cyanide thus employed is described as "powdered hydrocyanic acid," and contains an average of 55 per cent. cyanogen. (See Calcium Cyanide and Cyanamide.)

In a pure state it may be obtained by passing hydrogen sulphide over dry mercuric cyanide: $Hg(CN)_2 + H_2S = 2(HCN) + HgS$. It is also produced by action of the silent electric discharge on a mixture of cyanogen and hydrogen, and one of the commercial processes of production is conducted by the passage of a dried mixture of hydrogen, ammonia, and either carbon monoxide, carbon dioxide, or acetylene over heated platinized pumice.

With respect to its catalytic formation from ammonia and carbon monoxide, see P. V. Zimakov (*B.C.A.*, 1930, A, 43) and Bredig and Elöd (*B.C.A.*, 1931, A, 577), and its preparation by oxidation of ammonium thiocyanate or thiocyanic acid (Gluud and Keller, *B.C.A.*, 1931, B, 568).

HYDROCYANIC ACID (*Continued*)—

Solutions of calcium cyanide, when boiled, yield all the cyanogen as hydrocyanic acid, and moist carbon dioxide at a pressure lower than atmospheric is stated to effect a quantitative liberation of the acid from sodium or calcium cyanide without loss from polymerization (F. V. Bichowsky, *J.C.S., Abs.*, March, 1925, I., 236). It is also manufactured from cyanamide and sodium chloride with single-phase electric current and subsequent treatment with sulphuric acid.

In closed containers, explosions are apt to occur owing to the generation of gas caused by exothermic polymerization and decomposition of the liquid. Upon keeping in contact with water, it undergoes change into ammonium formate: $HCN + 2H_2O = NH_4CHO_2$. It is soluble in water, alcohol, and ether, and by combination with bases forms cyanides; a large number of double cyanides are also known.

The leaves of Sudan grass yield, it is stated, hydrocyanic acid upon digestion of the macerated material by the action of enzymes; it is also a constituent of the juice of the tapioca plant, and cherry-laurel leaves contain about 0·253 per cent.

The effects on foods of fumigation with hydrogen cyanide is the subject of a report by G. W. Monier-Williams (H.M. Stationery Office); see also articles on fumigation with hydrogen cyanide by W. G. Liston (*Chem. and Ind.*, 1925, **44**, 367), and by P. Buttenberg (*B.C.A.*, 1929, B, 575); "Studies on Hydrogen Cyanide," by Hinkel and Dunn (*J.C.S.*, 1930, p. 1834); and a review of the industrial uses of the soluble cyanides (*C.T.J.*, 1931, **89**, 243).

HYDRO-EXTRACTORS—See Centrifuges.

HYDRO-FERRICYANIC ACID—See Cyanogen Compounds.

HYDRO-FERROCYANIC ACID—See Cyanogen Compounds.

HYDROFLUORIC ACID—See Fluorine Compounds.

HYDROFLUOSILICIC ACID—See Silicon Compounds.

HYDROGEN (H) **and its Compounds**—Atomic weight, 1·00778, according to the mass-spectrograph determination; m.p., − 259° C. Hydrogen does not exist to any considerable extent in nature in the free gaseous state, although it is believed to be present in very large amount in the atmosphere of the sun. At ordinary temperatures it is a colourless gas, soluble to some extent in water (1 volume of which at 0° C. dissolves 0·021 volume of the gas), is without taste or smell, and is the lightest known substance, so that the relative weights of all other elements were until recently generally compared with hydrogen as the unit.

The hydrogen atom is credited with having the greatest possible mass for one proton.

It has been practically demonstrated by Paul Anson that hydrogen is activated by contact action of the platinum metals, and this activity remains to some extent upon desorption. The activity of the catalyst

HYDROGEN (*Continued*)—

when produced *in situ* is superior to that of the preformed agent. In terms of the quantum theory, the molecule takes up a quantum or more of energy, and reaches internal equilibrium only after a given period succeeding its desorption.

M. Poljakov reports that when hydrogen is circulated over a palladium plate previously heated to 700° to 800° C. and cooled at 1 to 5 mm. to 300° to 400° C. a violet luminescene is observed (*B.C.A.*, 1928, A, 1308).

It can also be activated by bubbling through molten sodium or by the action of heat and water on sodium hydride.

It had previously been found (by Wendt and Landauer) that an unstable active modification of hydrogen can be obtained (1) by the action of alpha rays; (2) by alternating discharges at low pressures; and (3) by passage through the corona at ordinary pressure. This activity is stated not to be due to ions or to atoms, and as a contraction in volume takes place, these investigators think that the activated hydrogen is triatomic. Another investigator attributes the properties of active hydrogen to a monatomic condition (see K. Bonhoeffer, *J.S.C.I.*, 1925, *Abs.*, B, 9); whilst its conversion into helium in small degree has been claimed by Paneth and Peters (*Chem. and Ind.*, 1926, **45**, 908). According to a recent report by K. Bonhoeffer, hydrogen consists of two forms of gas differing in boiling and freezing points which he describes as ortho-hydrogen and para-hydrogen (*B.C.A.*, 1929, A, 982 and 1372). As to the conversion of the *para* into the *ortho* hydrogen, see A. Farkas (*B.C.A.*, 1931, A, 174).

Metals, certain oxides, and other substances, when introduced into a stream of atomic hydrogen, are raised to incandescence owing, it is said, to the surface of the substance acting as a catalyst in bringing about the re-combination of the atoms; while hydrogen produced by blowing a current of hydrogen from a narrow tube into the arc is capable of melting molybdenum and tungsten with ease.

In its ordinary form, hydrogen is a comparatively inactive substance, but in its active form it is capable of reducing potassium permanganate to the lower manganate, indigo blue to indigo white, and combining with nitrogen to form ammonia. This activated hydrogen—sometimes described as "hyzone" (H_3)—is, however, very unstable, and is stated to revert to the inactive state in less than one minute.

Under pressure it acquires active properties, and in contact with some materials, such as the dust of iron oxide, hydrogen will ignite, due, as it appears from experiments that have been made to ascertain the cause, to a brush discharge from the electrified dust.

Hydrogen gas is inflammable, and when a stream of it is burned in the air or oxygen gas it forms water by combination ($2H_2 + O_2 = 2H_2O$).

A mixture of hydrogen and oxygen gas (or air) in certain proportions will explode when a light or electric spark is applied to the mixture, water being thus produced in the same way as when a stream of hydrogen is burned in the air. It has been shown, however, that mixtures of hydrogen and oxygen, which have been desiccated by pro-

HYDROGEN (*Continued*)—

longed exposure to phosphoric oxide, can be heated to redness in Jena glass tubes without explosion occurring, although slow combination ensues upon heating in presence of the least degree of moisture. H. B. Baker and Miss M. Carlton have shown that when the gases have been dried for seven or eight weeks, there is no appreciable contraction after some hours' exposure to ultra-violet light produced by a quartz mercury lamp, and therefore no formation of water.

It can be reduced to the liquid state, in which it is as clear and colourless as water.

The gas is easily made in the laboratory by the action of dilute sulphuric acid upon the metal zinc ($Zn + H_2SO_4 = ZNSO_4 + H_2$)—that is to say, the metal is attacked and dissolved by the acid, forming zinc sulphate, which passes into solution, the hydrogen escaping in the form of gas. It is also obtainable from coke-oven gas, which contains approximately 50 per cent. hydrogen.

Hydrogen, prepared by industrial processes, is now largely used in the oxyhydrogen flame for welding; also to fill the bags or floating chambers of airships, zeppelins, etc., and in a number of industries, including the production of methyl alcohol, liquid fuels, and ammonia; the hydrogenation of oils for use in the manufacture of soap and margarine, the oils being converted by this process into solid fats by the assimilation or absorption of hydrogen; for example, oleic acid ($C_{18}H_{34}O_2$) absorbs 2 atoms hydrogen, and becomes converted into stearic acid ($C_{18}H_{36}O_2$). A new use for hydrogen by the General Electric Co., Schenectady, is that for cooling enclosed moving electrical machinery, which will thus handle 50 per cent. more power without increasing the safety limit in point of temperature.

The hydrogen for these and other purposes may be prepared by several processes, one of which is conducted by passing steam over coke at a high temperature, 6 tons of coke yielding about 1 ton of hydrogen; another is carried out by passing the vapour of water at a high temperature over iron prepared in a spongy condition, by which the oxygen combines with the iron and the hydrogen gas is set free. One of the best-known plants for effecting this process is the "Lane-Rogers," as installed by the Fuel Research Board, and it has been found that iron oxide deposited on pumice stone reacts more effectually than the spathic iron ore when used in the same plant. In the "Bosch" process a mixture of steam and water gas is passed over a catalyst at about 400° to 500° C. Another process is conducted by the electrolysis of an aqueous solution of caustic soda in a series of cells, the hydrogen being evolved at one pole of the generator and the oxygen at the other, and collected separately.

The greater quantity is still made by the reduction of steam, although it is generally conceded that electrolytically-made hydrogen, by reason of its freedom from catalyst poisons, is the best for hydrogenation processes, and the description of a "Knowles" plant will be found in *Chem. and Ind.*, 1925, **44,** 131. Other cells used in the electrolytic production of hydrogen are referred to under the headings of Electri-

HYDROGEN (*Continued*)—

city (p. 291); A. E. Knowles (*C.T.J.*, 1925, **77,** 589); J. B. C. Kershaw (*Ind. Chem.*, 1925, i., 98, 149, and 206); W. G. Allan (*C.T.J.*, 1925, **77,** 509); *C.T.J.*, 1926, **78,** 67); and D. M. Newitt (*C.T.J.*, 1932, **90,** 102).

A "cracking" process, conducted by the passage of ammonia gas over a catalyst at 600° C., is at present attracting considerable attention, and although this quality of hydrogen (75 per cent.) is not good enough for oil hydrogenation the product, containing 25 per cent. nitrogen, is probably usable for the cutting of metals, the reduction of metallic oxides, and in other manufacturing operations.

Electrolytically prepared hydrogen can only be used for many purposes where electric energy is both cheap and abundantly available, approximately 140 kw.h. per 1,000 cubic ft. gas being necessary, while the oxygen simultaneously produced cannot be utilized except under favourable and exceptional conditions.

The "Silicol" process consists in the decomposition of silicon alloys, such as ferro- or mangano-silicons (obtained in the electric furnace), by a strong solution of caustic soda containing from 35 to 40 per cent. of NaHO, the heat generated by the soda solution being sufficient to start the reaction, $Si + 2NaOH + H_2O = Na_2SiO_3 + 2H_2$.

Hydrogen can also be made by the action of water on an alloy of magnesium and lead, while the "Linde-Frank-Caro" process operates by liquefying all the constituents of water gas except hydrogen.

Another method depends upon the catalytic oxidation of the carbon monoxide of water gas by superheated steam, and then separating the carbon dioxide thus formed from the remaining hydrogen by underpressure through water. The "Urbain-Auger" process depends upon the exothermic oxidation of phosphorus. (See *C.T.J.*, 1927, **80,** 624); and there are also several biochemical processes by which hydrogen can be made, one of which is referred to under the heading of Acetone.

There are two compounds of hydrogen and oxygen—viz., water (H_2O) and hydrogen dioxide (peroxide) (H_2O_2). With the halogens, it forms the four acids known as hydrochloric (HCl), hydrobromic (HBr), hydriodic (HI), and hydrofluoric (HF).

Combinations of hydrogen with nitrogen and oxygen are known in the forms of nitrous acid (HNO_2), and nitric acid (HNO_3); and with sulphur and oxygen in the forms of sulphurous and sulphuric acids (H_2SO_3 and H_2SO_4).

Hydrogen is a constituent of innumerable organic compounds, including the hydrocarbons, and with carbon and nitrogen it forms hydrocyanic acid (HCN). With sulphur alone it forms the compounds hydrogen sulphide (H_2S) and hydrogen persulphide (H_2S_2), an oily liquid of sp. gr. 1·376 and unstable character. With nitrogen alone it exists in combination as ammonia (NH_3), and it forms so-called hydrides with many metals, such as arsenic and antimony, the arsenical compound being what is otherwise known as arseniuretted hydrogen (AsH_3).

"The Photo-chemical Union of Hydrogen and Chlorine" is the sub-

HYDROGEN (*Continued*)—
ject of papers by Allmand and Beesley (*J.C.S.*, 1930, pp. 2693-2721); the permeability of hot metals to hydrogen is dealt with by Hendricks and Ralston (*B.C.A.*, 1930, A, 26); and the "Production of Hydrogen by Micro-organisms," by A. C. Thaysen (*Chem. and Ind.*, 1926, **45,** 71); see also Coke Ovens and Water Gas.

Hydrogenation is a process available for the production of petrol and oil from the crude products of coal carbonization. As applied to fatty oils it is brought about by the influence of so-called *catalytic agents,* the metal nickel (from 0·25 to 1 per cent. of the weight of the oil) being most economically used for this purpose in association with silicates (such as the kieselgühr which comes from Stavanger, Norway) or other materials. Generally, nickel carbonate or hydroxide is deposited on the carrier, and subsequently reduced to metallic nickel at about 350° C., but sometimes gaseous nickel carbonyl is used. The purity of the nickel is of importance, the catalytic poisons to be suspected in association with nickel salts being lead, zinc, and sulphur. (See Nickel.) Nickel carbonate precipitated upon the carrier in a crystalline condition would appear to exhibit special qualifications. Palladium, platinum, cobalt, and other metals can also be used as catalysts.

The catalytic agent has, of course, to be brought into contact with the cleaned oils to be treated, and the mixture heated to from 160° to 200° C. in purified hydrogen at a pressure of about 10 atmospheres, and there are many modifications of plant for effecting this. Many oils, such as whale oil, otherwise difficult to purify and having objectionable properties, are thus deodourized and turned into solid fats more easily and economically adapted for soap-making, or made more or less fit for edible use, while it is also possible to increase the melting-points of vegetable oils, thus rendering them available for making margarine.

There is a so-called hydrogenation odour and flavour attached to these commercial products obtained from fish and vegetable oils, originating, as suggested, in the formation of some volatile aldehydic and ketonic bodies, and only when this difficulty is overcome can the hydrogenated oils be used in compounding delicate edible products. The best method, so far known, of deodourizing hardened fats is by exposure under ordinary pressure to a mixture of carbon dioxide and nitrogen for a period of from 40 to 50 minutes.

Fat-hardening in Switzerland is chiefly applied to the oils obtained by cold pressure from sesame seed and ground nuts. After refining, they are mixed with the catalyst (very finely divided nickel oxide or salt) and heated to from 100° to 260° C. in a high steam-jacketed autoclave, the hydrogen (which is prepared from water by the electrolytic method) being introduced through pipes into the mixture. (See Waterman and Bertram (*J.S.C.I.*, 1929, **48,** 79 T); R. A. Bellwood (*C.T.J.*, 1925, **76,** 291); E. J. Lush (*J.S.C.I.*, 1924, **43,** 53 T); and 1925, **44,** 129 T); (*Ind. Chem.*, 1927, iii., 197, 249, and 309); (*Chem. and Ind.*, 1927, **46,** 572); Kaufmann and Hauser-Schmidt (*Analyst*, 1927, **52,** 246); T. Andrews on "Oil Impurities as Catalytic Poisons (*C.T.J.*, 1929, **84,** 277, 302, 351, and 369); E. J. Lush on "Hydrogenation of Organic

HYDROGEN (*Continued*)—

Compounds" (*Ind. Chem.*, 1930, vi., 142); E. F. Armstrong on "Fat Hydrogenation" (*Chem. and Ind.*, 1931, **50**, 968; and 1932, **51**, 92); and Oils (Hydrogenation), p. 638.)

Hydrogenation is a process of importance in the production of synthetic ammonia; in the preparation of cyclohexane from benzene; of tetralin and allied products from naphthalene; and the possible production of aniline by a catalytic process from nitro-benzene, etc. The hydrogenated phenols like hexalin have many industrial applications by reason of their powerful solvent and emulsifying properties. (See Dekalin, Hexalin, and Hydrogenated Phenols.) See "Pressure Hydrogenation" (*Ind. Eng. Chem.*, October, 1930), or extracts therefrom (*C.T.J.*, 1930, **87**, 403); "Hydrogenation of Fuels," by Levi and others (*B.C.A.*, 1930, B, 1053); *Hydrogenation of Organic Substances*, by C. Ellis (Routledge and Sons); Berginization, Coal, and Nitrogen Fixation.

HYDROGEN CHLORIDE—See Chlorine.

HYDROGEN CYANIDE—See Hydrocyanic Acid.

HYDROGEN DIOXIDE or **PEROXIDE OF HYDROGEN** (H_2O_2) is nearly related to water, and differs therefrom in that its molecule contains 1 atom more oxygen. It can be prepared in a number of ways, one of which consists in mixing barium dioxide (BaO_2) with dilute sulphuric acid, when the following interaction takes place: $BaO_2 + H_2SO_4 = BaSO_4 + H_2O_2$. It can also be prepared from sodium peroxide (see Kilpatrick, Rieff, and Rice, *B.C.A.*, 1927, A, 120).

Another method consists in treating barium dioxide in the presence of water with carbon dioxide under pressure. The dilute solution of hydrogen dioxide resulting from these processes, after separation from the insoluble barium sulphate or carbonate, can be concentrated to some extent by evaporation, or it can be purified by distilling at a low pressure and concentrated up to 90 per cent. by an appliance known as the "sulphuric acid concentrator," and from this solution 100 per cent. peroxide can be obtained by fractional freezing. A further process for making it is by electrolyzing sulphuric acid (using a platinum anode), and the subsequent conversion of the persulphuric acid thus produced into hydrogen dioxide. It is stated that sodium persulphate can be produced to a greater degree of concentration than the free acid, and that distillation of the once recrystallized sodium salt gives reasonably high yields of the peroxide. By electrolysis $2KHSO_4$ gives $K_2S_2O_8$ and H_2; by distillation, $K_2S_2O_8$ and $2H_2O$ gives $2KHSO_4$ and H_2O_2. (See G. Teichner (*Chemiker Zeitung*, No. 42, 1931.)

What is described as an improved process is one which combines the advantages of the persulphuric acid method with that of the ammonium persulphate method. (See *C.T.J.*, 1929, **85**, 418.)

It is produced in appreciable quantity when air or oxygen is rapidly passed through water containing palladium foil thoroughly saturated with hydrogen.

It is always found amongst the products which result when ether,

HYDROGEN DIOXIDE (*Continued*)—

phosphorus, turpentine and terpenes generally are exposed to air and moisture, so that it is always present in the air of pine woods and eucalyptus forests, also following lightning discharges, and under some other circumstances.

The urea compound named "hyperol" yields hydrogen dioxide by hydrolysis with water. (See "Hyperol.")

The pure peroxide is quite stable if kept at 0° C.; its freezing-point is $-1{\cdot}7°$ C., and its sp. gr. at 0° C. is 1·4633. It decomposes in contact with wood, and in presence of a trace of acid the wood takes fire; it also attacks glass. A 60 per cent. solution is liable to cause engine-used woollen waste to take fire, but clean waste out of contact with any catalytic agent will not take fire when in contact with a solution of this strength. As ordinarily prepared, it is often unstable and in concentrated forms is apt to decompose with explosive violence.

Hydrogen dioxide readily parts with its second atom of oxygen, as, for instance, in neutral solution by cobaltic hydroxide in suspension, and is a very valuable sanitary and oxidizing agent, being one of the constituents of the disinfectant "Sanitas" Fluid.

Its *antiseptic* properties were first demonstrated by the author of this encyclopædia. (See *Chem. News*, 1899, **80**, 34.)

Solutions of it in water are largely used for bleaching straw, hair, ivory, oils and other articles, also as a preservative of foods, and in the practice of surgery, on account of its antiseptic character and its power to destroy septic matter in wounds by oxidation. To expedite its bleaching effects it must be made slightly alkaline by the agency of a small proportion of ammonia, borax, or, best of all, sodium silicate supplemented by warmth in certain cases.

It is odourless and colourless like water, to which substance it is reduced when decomposed ($H_2O_2 = H_2O + O$).

It is soluble to some extent in alcohol, and a dilute solution of it in water can be used to restore oil and other paintings which have become discoloured owing to the formation of lead sulphide (through exposure to air containing sulphur), by reason of its power of oxidizing the black sulphide into white lead sulphate. For its preservation against loss of strength by spontaneous decomposition, use is made of minute additions of various agents, including acetanilide, quinine sulphate, camphoric acid, alcohol, ether, etc.

It is marketed in various strengths, 10, 12, and up to 100 volumes being ordinary commercial forms—that is to say, aqueous solutions containing sufficient to yield 10, 12, and 100 times their own volume of oxygen gas upon decomposition. A review of manufacturing processes by Dr. Weshing is given in the *C.T.J.*, 1926, **79**, 252; see also Allmand and Style on "The Photolysis of Aqueous Hydrogen Dioxide Solutions" (*J.C.S.*, 1930, pp. 596-623).

HYDROGEN-ION and its Determination—There are methods for determining the hydrogen-ion concentration in wines, dye-baths, tanning liquors, etc., and for standardizing indicators. A solution containing

HYDROGEN-ION (*Continued*)—

one gram equivalent of hydrogen-ion is the normal one used in determining *p*H values. In the ordinary electrometric measurement a platinized platinum electrode—*i.e.*, a bright piece of platinum on which a thin layer of platinum black has been electrically deposited—is used. This is capable of occluding a considerable volume of hydrogen gas and is partly immersed in the solution under examination, a stream of hydrogen gas being meanwhile bubbled through. This enables the hydrogen occluded in the platinum black to enter into equilibrium with hydrogen gas under a pressure of one atmosphere, and when a steady stage is reached the potential of the electrode is measured against that of a standard half-element—usually the calomel electrode—to which connection is made by a junction containing saturated potassium chloride solution; this being necessary to eliminate any potential which may be established at the point of contact of the two electrode liquids. From the result obtained and the potential of the standard half-element used, the potential of the hydrogen electrode E can easily be found. This value $E = 0{\cdot}000{,}198{,}4^{\times}\ (273 + t^{\circ}\ C.) \log [H^{\cdot}] = 0{\cdot}000{,}198{,}4(273 + t)pH$. This formula permits the calculation of hydrogen-ion concentrations in gram-equivalents of ions per litre or merely gram-ions per litre and the calculation of the *p*H value.

The relation between hydrogen-ion concentration and *p*H will be understood from the example: let $[H^{\cdot}] = 10^{-x}$ gram-ions per litre, then x is the *p*H value, sometimes known as the Sørensen value. A solution containing one gram equivalent of hydrogen-ions may be represented as of concentration $10^{\circ}(=1)$, and therefore the corresponding *p*H is O. S. Glasstone has described a modified method which dispenses with the use of the hydrogen stream, but this method is of very restricted application.

References: A new type of Triode valve in connection with glass electrodes, by G. B. Harrison (*J.C.S.*, 1930, p. 1528); an improved type of glass electrode, by MacInnes and Belcher (*B.C.A.*, 1931, A, 1268); S. Glasstone (*Analyst*, 1925, **50,** 327); H. T. S. Britton (*Ind. Chem.*, 1927, iii., 149, 220, 257, 314, 362, 452, and 508; 1928, iv., 49 and 150; and 1929, v., 160); T. H. Fairbrother (*Ibid.*, 1928, iv., 66 and 93); Robertson and Smith (*J.S.C.I.*, 1930, **49,** 120 T); Fletcher and Westwood on "Possible Sources of Error in *p*H Determinations" (*J.S.C.I.*, 1930, **49,** 201 T); J. Grant respecting "A Simple Ruler for the Interconversion of Electromotive Force Readings and *p*H Values," etc. (*J.S.C.I.*, 1930, **49,** 302 T); "Recent Developments in the Colorimetric Determination of Hydrogen-ions," by McCrumb and Kenny (*J.S.C.I.*, 1930, **49,** 426 T and 428 T); S. P. L. Sôrensen on "Hydrogen-ion Concentration" (*J.S.C.I.*, 1931, **50,** 278 T); G. M. Moir on the "Quinhydrone Electrode" (*Analyst*, 1931, **56,** 445); J. G. Davies on the same subject (*Ibid.*, p. 449); C. Morton on "An Automatic *p*H Recorder" (*J.S.C.I.*, 1931, **50,** 436 T); *Hydrogen-Ions: their Determinations*, etc., by H. T. S. Britton (Chapman and Hall, London); H. T. S. Britton's *Hydrogen-ions Concentrations* (Chapman and Hall); W. M. Clark's *The Determination of Hydrogen-ions* (Baillière, Tindall and Cox); and

HYDROGEN-ION (*Continued*)—
J. Grant's *Measurement of Hydrogen-ion Concentration* (Longmans, Green and Co). See also *p*H Values and Volumetric Analyses.

HYDROGEN SULPHIDES—See Sulphur Compounds.

HYDROGENATED PHENOLS—The use of hexa-hydrogenated phenol for improving the detergent and cleansing power of soaps (particularly those used for scouring wool, yarn, felt, and other textiles) is referred to elsewhere under the headings of "Hydrogenation," "Hexalin," "Sextate," "Sextol," "Sextone," and "Soaps." The various preparations made for this and other applications are made by the hydrogenation of phenol in the gaseous phase at about 180° C. in the presence of a catalyst such as active nickel reduced from its oxide. Cyclohexanol, the active principle of the resulting product, has a sp. gr. of 0·945, b.p. 160° C., flash-point of 68° C., and can be used as a solvent or emulsifying agent for fats, oils, waxes, resins, acetyl-cellulose, etc. Further particulars will be found in *C.T.J.*, 1925, **76,** 737.

HYDROGENATION—See Hydrogen (Hydrogenation) and Oils.

HYDROLYSIS—The splitting up of a more or less complicated substance into simpler or proximate bodies; enzymes, acids, and alkaline hydrates being the agents (hydrolysts) often employed for this purpose. The process in general is one of water-splitting, the H entering into combination with one product and the HO group with another. For example, methyl acetate upon hydrolysis yields methyl alcohol and acetic acid ($CH_3COO.CH_3 + H_2O = CH_3COOH$ and CH_3OH). Fat-splitting is another instance of what is known as "hydrolytic" action or hydrolysis. (See Fats, p. 335.)

HYDROMETERS—Appliances for determining the approximate specific gravities of liquids, generally consisting of a graduated sealed glass tube, swelling below to a globe, counterpoised by an adjusted weight which often takes the form of a small quantity of mercury imprisoned in another smaller bulb at the lower end. Such an appliance when placed in any liquid contained in a cylinder sufficiently deep, sinks until it has displaced a volume of the liquid equal to its own weight. In a heavy liquid it will sink to a smaller extent than in a lighter liquid. They are made for liquids lighter than water and for those which are heavier —but in both cases they are constructed so that a part of the graduated stem floats above the surface of the liquid, the density of which is to be determined. Sikes's hydrometer for ascertaining the alcoholic strength of spirituous liquors is constructed on this principle, and there are tables made out so that the graduations on the stem correspond to definite percentages of alcohol, water being marked as zero of the standard. (See New Sike's "B" (*Analyst*, 1931, **56,** 810) and Proof Spirit.)

It is important in determining densities by means of hydrometers to pay great attention to the temperature, as small differences in that respect make considerable variations in the result. It is usual to

HYDROMETERS (*Continued*)—

Specific Gravities (Densities) on Baumé's Hydrometer for Liquids Lighter than Water at 15·56° C. or 60° F.

Degrees.	Sp. Gr.	Degrees.	Sp. Gr.	Degrees.	Sp. Gr.	Degrees.	Sp. Gr.
10	1·0000	26	0·8974	41	0·8187	56	0·7527
11	0·9929	27	0·8917	42	0·8140	57	0·7487
12	0·9859	28	0·8861	43	0·8092	58	0·7447
13	0·9790	29	0·8805	44	0·8046	59	0·7407
14	0·9722	30	0·8750	45	0·8000	60	0·7368
15	0·9655	31	0·8696	46	0·7955	61	0·7330
16	0·9589	32	0·8642	47	0·7910	62	0·7292
17	0·9524	33	0·8589	48	0·7865	63	0·7254
18	0·9459	34	0·8357	49	0·7821	64	0·7216
19	0·9396	35	0·8485	50	0·7778	65	0·7179
20	0·9333	36	0·8434	51	0·7735	66	0·7143
21	0·9272	37	0·8383	52	0·7692	67	0·7107
22	0·9211	38	0·8333	53	0·7650	68	0·7071
23	0·9150	39	0·8284	54	0·7609	69	0·7035
24	0·9091	40	0·8235	55	0·7568	70	0·7000
25	0·9032						

Specific Gravities (Densities) Corresponding to Degrees of Baumé's Hydrometer for Liquids Heavier than Water at 15·56° C. or 60° F.

Degrees.	Sp. Gr.	Degrees.	Sp. Gr.	Degrees.	Sp. Gr.	Degrees.	Sp. Gr.
0	1·0000	18	1·1417	36	1·3303	54	1·5934
1	1·0069	19	1·1508	37	1·3426	55	1·6111
2	1·0140	20	1·1600	38	1·3551	56	1·6292
3	1·0211	21	1·1694	39	1·3679	57	1·6477
4	1·0284	22	1·1789	40	1·3810	58	1·6667
5	1·0357	23	1·1885	41	1·3942	59	1·6860
6	1·0432	24	1·1983	42	1·4078	60	1·7059
7	1·0507	25	1·2083	43	1·4216	61	1·7262
8	1·0584	26	1·2185	44	1·4356	62	1·7470
9	1·0662	27	1·2288	45	1·4500	63	1·7683
10	1·0741	28	1·2393	46	1·4646	64	1·7901
11	1·0821	29	1·2500	47	1·4796	65	1·8125
12	1·0902	30	1·2609	48	1·4948	66	1·8354
13	1·0985	31	1·2719	49	1·5104	67	1·8590
14	1·1069	32	1·2832	50	1·5263	68	1·8831
15	1·1154	33	1·2946	51	1·5426	69	1·9079
16	1·1240	34	1·3063	52	1·5591	70	1·9333
17	1·1328	35	1·3182	53	1·5761		

HYDROMETERS (*Continued*)—

observe at a temperature of 15·56° C., or 60° F., at which temperature the hydrometer is graduated.

The degrees of Twaddell's hydrometer are convertible into corresponding specific gravities by multiplying them by 0·005 and adding 1·000.

DEGREES ON TWADDELL'S HYDROMETER, AND THE CORRESPONDING DENSITIES AT 15·56° C. OR 60° F.

Degrees.	Sp. Gr.	Degrees.	Sp. Gr.	Degrees.	Sp. Gr.	Degrees.	Sp. Gr.
1	1·005	11	1·055	21	1·105	31	1·155
2	1·010	12	1·060	22	1·110	32	1·160
3	1·015	13	1·065	23	1·115	33	1·165
4	1·020	14	1·070	24	1·120	34	1·170
5	1·025	15	1·075	25	1·125	35	1·175
6	1·030	16	1·080	26	1·130	36	1·180
7	1·035	17	1·085	27	1·135	37	1·185
8	1·040	18	1·090	28	1·140	38	1·190
9	1·045	19	1·095	29	1·145	39	1·195
10	1·050	20	1·100	30	1·150	40	1·200

A. C. Tester has described an apparatus for determining the density of liquids (5 c.c.) between 2 and 5 (*Science*, 1931, **73**, 130).

(See also Densities and Specific Gravities.)

"HYDRON BLUE"—A sulphur colour described as the modern rival of indigo.

HYDRONE—See Water.

HYDROQUINONE or QUINOL (**Dihydroxybenbene**) ($C_6H_4(OH)_2$)—A white, crystalline phenolic compound used in medicine and as a developer in photography on account of its strong reducing action. It melts at 169° C., and can be obtained by hydrolysis of the glucoside named arbutin, or by oxidation of quinic acid ($C_7H_{12}O_6$) with lead dioxide, etc. It is soluble in water, alcohol, and ether. (See Glucosides and Tanning).

"HYDROS"—An abbreviated (trade) name for sodium hydrosulphite ($Na_2S_2O_4$), used as a decolourizing agent, by removal of iron compounds from soap after the process of saponification is completed (2 to 3 lbs. being used for every 1,000 lbs. of fats); also for decolourizing sugar solutions during the refining process, and in calico-printing for discharging the colour in certain portions of the pattern. (See Hydrosulphites.)

"HYDROSOL"—See Colloid Chemistry, p. 227.

HYDROSULPHIDES (**Sulphydrates**) contain the group HS. If potassium be heated in gaseous hydrogen sulphide, potassium hydrosulphide is formed, hydrogen being at the same time set free: $H_2S + K = KHS + H$; and the same substance is produced in solution by passing a current of hydrogen sulphide into a solution of potassium sulphide: $H_2S + K_2S = 2KHS$.

HYDROSULPHIDES (*Continued*)—

Sodium hydrosulphide ($NaHS.2H_2O$) can be obtained in the form of colourless needles, soluble in water, by treating calcium sulphide with sodium bisulphate. (See Mercaptans.)

HYDROSULPHITES (**Salts of Hyposulphurous Acid,** $H_2S_2O_4$)—The sodium, calcium, and zinc hydrosulphites are all used in sugar refining; they act as decolorizers, and reduce the viscosity of the sugar liquors. The manufacture of the sodium compound in 10 to 12 per cent. solution is effected by interaction between sodium bisulphite and powdered zinc; or by the passage of sulphur dioxide gas into water containing zinc dust in suspension and conversion of the zinc hydrosulphite into the sodium compound by the addition of soda-ash. It can also be obtained by the electrolytic (cathodic) reduction of sodium bisulphate as expressed by the equation: $2NaHSO_3 + 2H = Na_2S_2O_4 + 2H_2O$.

Hydrosulphites are marketed in three forms—namely, sodium hydrosulphite, in white lumps or small white crystals readily soluble in water, having an odour of sulphur dioxide, and which acts without the addition of acid; another form—namely, a sodium compound—known as "formosul," usually employed in solution with formic or acetic acid; and zinc "formosul," which contains zinc instead of soda. This last is the most stable and powerful of the three, and is said to be the best to use for stripping. (See L. A. Pratt (*C.T.J.*, 1924, **75,** 65) and "Hydros.")

HYDROXIDES—A term reserved for compounds containing the group OH—*e.g.* KHO and $Al(OH)_3$. (See Bases.)

HYDROXYL (HO)—The monad (univalent) radical group which exists in many chemical combinations, such as the alcohols, and in hydroxylamine—that is, ammonia (NH_3), in which one of the hydrogen atoms is replaced by the group HO, becoming $NH_2(OH)$. (See Oximes.)

HYDROXYLAMINE, $NH_2(OH)$—A colourless, crystalline, basic derivate of ammonia of m.p. 33° C., used as a reducing agent, etc. It may be regarded as ammonia in which a hydrogen atom is replaced by the hydroxyl group (OH). It is prepared by the action of nascent hydrogen upon nitric oxide or nitric acid, the hydrogen being generated from tin and hydrochloric acid, and in their presence hydroxylamine hydrochloride is formed. From this salt, when separated, hydroxylamine is generated by decomposition with a base and distillation *in vacuo*.

It decomposes with explosive violence if heated to about 100° C., and forms definite salts with acids without the elimination of water. The hydrochloride is used as a photographic developer.

HYGIENE (**Chemistry**)—See "Hygiene, Industrial, Chemistry of" (Klear) (*B.C.A.*, 1926, B, 998); Kingzett's *Nature's Hygiene* (fifth edition) and *Pocket Dictionary of Hygiene* (second edition), by Kingzett and Homfray (Baillière, Tindall, and Cox); *Theory and Practice of Hygiene*, by Notter and Firth (J. and A. Churchill); R. Robertson's "History of

HYGIENE (*Continued*)—
Legislation" (*C.T.J.*, 1924, **75**, 183); *Practical Sanitation*, by G. Reid (Sanitary Publishing Co., Ltd., Breams Buildings, London, E.C. 4); *A Textbook of Hygiene*, by J. R. Currie (E. and S. Livingstone, Edinburgh); and *Hygiene*, by R. C. Whitman (Chapman and Hall).

HYGROGRAPH—The so-called clock-driven baro-thermo-hygrograph (Negretti and Zambra) records on one chart with three distinct traces the barometric pressure, temperature, and humidity. "Casella's hair hygrograph" is an instrument for recording on a chart percentages of humidity based on the property of human hair, when freed from fat, of expanding in moist air and contracting in dry air. A bundle of hair is held by two jaws, and at the centre supports a hook attached to a system of levers; the tension of the bundle of hairs actuates the recording pen through a pair of cams working on each other. (See Humidity and Hygrometers.)

HYGROMETERS—Special varieties of these instruments are made for determining the humidity of the air in timber, leather, and paper-drying rooms; there is also a "whirling" make recommended by the "Hot and Deep Mines" Temperature Committee, etc.

References: The "Edney" hair hygrometer acts by the contraction or expansion of a strand of fifty specially treated hairs which alters in length according to the percentage of moisture in the air, the movement being conveyed to an indicator. A hygrometer employing glycerine has been described (*Chem. and Ind.*, 1926, **45**, 904), and another sensitive one based on the difference in density between atmospheric air and air saturated with aqueous vapour. (Romberg and Blau, *B.C.A.*, 1927, A, 128.) Various forms are described by E. Griffiths (*Jl. Inst. Chem.*, Part III., 1928, p. 149). A new recording one (*Ind. Chem.*, 1931, vii., 425). The Measurement of Humidity in Closed Spaces is the subject of a special Report of the Food Investigation Board (No. 8, 1925, 54 pp.); report on "The Measurement of Humidity in Closed Spaces" (*Analyst*, 1926, **51**, 35); "A Constant Humidity Room," by Parker and Jackman (*J.S.C.I.*, 1925, **44**, 223 T); "Apparatus for Automatic Humidity Control," by Apthorpe and Hedges (*J. Sci. Inst.*, 1927, **4**, 480); "A Laboratory Humidity Cabinet," by Matthews and Burgess (*Ind. Eng. Chem.*, 1928, **20**, 1239); one for use in timber seasoning kilns described by E. Griffiths (*B.C.A.*, 1929, B, 598); and Hygrograph.

HYGROSCOPIC—The property of absorbing moisture from the air. This is not limited to solids; sea water, for example, is capable of absorbing moisture from the air when saturated with it at the same temperature.

HYLOTROPIC PHASES—Phases limited to the identification of the purified products of chemical reactions without studying the exact character or nature of the reacting causes. In other words, the term relates to bodies susceptible of change of phase as from liquid to vapour without change in composition.

HYOSCINE (**Scopolamine**)—An alkaloid of m.p. 59°, soluble in alcohol and ether, obtained from plants of the order Solanaceæ; the lævo

HYOSCINE (*Continued*)—
variety is said to be much more physiologically active than the inactive form. The hydrobromide is used as a mydriatic. (See Henbane.)

HYOSCYAMINE ($C_{17}H_{23}NO_3$)—From *Hyoscyamine niger* (henbane), m.p. 108°, sublimable, soluble in water and alcohol, and isomeric with atropine. The oil extracted from the seeds by light petroleum is stated to have *d* 0·921; acid v. 23·60; sap. v. 187·70; i.v. 135·70; Reichert-Meissl v. 1·06 (Bures and Kracik, *B.C.A.*, 1929, B, 825). (See Atropine, Belladonna, and Henbane.)

Hp VALUES—See *p*H and Volumetric Analyses.

"HYPEROL"—The registered name of a white crystalline compound of hydrogen dioxide and urea ($CO(NH_2)_2H_2O_2$), which yields 35 per cent. H_2O_2 by hydrolysis with water.

One gramme dissolved in 10 c.c. water yields a 10-vol. solution of peroxide in association with the urea. (See *J.S.C.I.*, 1925, **44** (Supplement), vol. iii., 1137; and Löwenstein (*Ind. Chem.*, 1929, v., 538).)

HYPO—A prefix in chemical nomenclature used to distinguish a particular compound from other members of a series, as, for example, nitr*ous* and nitr*ic* acid, the term hyponitrous acid indicating the acid containing the least oxygen. HNO_2 is nitrous acid, HNO_3 is nitric acid, and $H_2N_2O_2$ is hyponitrous acid.

"HYPO"—This trade term is also used as a common name for sodium thiosulphite (hyposulphite) of sodium.

HYPOCHLORITES—Salts of hypochlorous acid. (See Chlorine Compounds.)

HYPOCHLOROUS ACID—See Chlorine Compounds.

HYPOPHOSPHOROUS ACID—See Phosphorous Compounds.

HYPOSULPHITE OF SODIUM—See Sodium Compounds.

HYPOSULPHUROUS ACID—See Sulphur Compounds.

HYPOTHESIS—A conjectural or speculative view of matters not in opposition to ascertained facts.

HYSSOP OIL—A colourless essential oil distilled from the herb *Hyssopus officinalis* (N.O. Labiatæ), the yield being 0·4 per cent.; soluble in alcohol and ether, of sp. gr. 0·932, and used in perfumery, medicine, and liqueur-making. (See Rutovski, *B.C.A.*, 1928, B, 768, for other details.)

HYZONE—See Hydrogen.

"IALINE"—A disinfectant of coal-tar nature miscible with water.

ICE—See Water; also footnote in Heat section (p. 435).

ICE (DRY)—See Carbon Oxides (p. 146).

ICELAND MOSS—A lichen (*Cetraria islandica*) which grows abundantly on the coasts of Norway, Iceland, and other northern parts; it contains a mucilage which can be extracted by hot water and is used as food and in medicine. (See Fumaric Acid.)

ICELAND SPAR—See Calcium.

ICHTHYOCOLL—See Isinglass.

"ICHTHYOL"—The registered trade-mark name of an indefinite mixture of sulphonated hydrocarbons obtained by the dry distillation of certain sulphurized bituminous shales such as the Seefeld schist. It is marketed as a reddish-brown, syrupy, liquid ammonium salt of ichthyol-sulphuric acid, prepared by neutralizing that acid (as obtained from the crude oil by treatment with sulphuric acid) with ammonia. It is used as an antiparasitic and as an irritant in certain skin affections. The oil from Kashpir shale differs from that produced from the Scottish shale. (See Rakovski and Sokolov (*B.C.A.*, 1930, B, 1099).)

"ICYL"—A group of colours presenting certain advantages with respect to dyeing viscose silk substitutes. (See Dyes and Silk Substitutes.)

IGNITION—Setting on fire or taking light. A piece of paper ignites on applying a lighted match. A jet of coal gas takes light in the same way, and both the paper and the gas are thus ignited and burn with production of light and heat. The temperature at which combustion of a substance takes place is known as its ignition-point. It is not always necessary to apply a light to cause combustion; phosphorus takes fire on exposure to the air, and if sodium be warmed in the air it also will burn, forming the peroxide (Na_2O_2). Again, lime in slaking develops sufficient heat to set fire to wood in close proximity.

The "ignition temperature" of gases may be roughly described as the lowest at which a mixture of combustible gas and air or oxygen will undergo chemical change, thus producing flame. (See Wall and Wheeler (*J.C.S.*, 1927, p. 291), and Naylor and Wheeler (*Ibid.*, 1931, p. 2456).) "This 'lag' in ignition, usually defined as the interval in time between the rapid heating of the mixture to or above a certain minimum temperature called the ignition-point and the appearance of flame," is a function of several conditions. (See J. S. Lewis, *J.C.S.*, 1930, p. 2241; and Flame, Flash-Point.)

ILANG-ILANG OIL—See Ylang-ylang.

ILLICIUM OIL—See Aniseed Oil.

ILLINIUM (Il)—Name given to what is supposed to be an element (61st place in atomic number scale), said to have been discovered in certain rare earths by B. S. Hopkins of Illinois. L. Rolla and L. Fernandes claim to have discovered an element of the same atomic number, which they name "florentium."

ILLIPÉ TALLOW—An edible fat from the illipé nuts of Borneo, Indo-China, Sumatra, and neighbouring islands, obtained from various dipterocarp trees, including *Shorea stenoptera* (Burck), distinct, however, from the Indian nuts yielded by species of *Bassia* (Sapotaceæ), which give the softer fat known as illipé *butter*.

The component glycerides of Borneo (Illipé) tallow was the subject of a recent investigation by Hilditch and Priestman, the specimen in question exhibiting a m.p. of 36° to 36·5° C., sap. v. 290·7, i.v. 32·3, while the mixed fatty acids comprised stearic acid 39 per cent., oleic acid 38 per cent., palmitic acid 21·5 per cent., and myristic acid 1·5 per cent. (*J.S.C.I.*, 1930, **49**, 196 T).

ILLIPÉ TALLOW (*Continued*)—

There is much confusion concerning the product known variously as illipé "tallow," "butter," and "nut oil," all derived from various families of so-called butter-trees. For instance, kernels from the Kinabatangan district, containing 6·9 per cent. moisture, are stated to yield (by extraction with petroleum) 44·8 per cent. fat, which has the general character of Borneo tallow, with an acid value of 11·4 as compared with previous samples, reported at from 45 to 73. The residual meal contains 10·3 per cent. protein, and constitutes a cattle foodstuff. Again, Singapore nuts are stated to yield 50 to 55 per cent. oil, sp. gr. 0·9021 at 40°/4° C., m.p. 39° to 40° C., i.v. 50 to 64, and sap. v. 188·4. (See M. Tsujimoto (*Analyst*, 1930, **55,** 212.)

ILMENITE—A mineral compound of iron and titanium oxides, $(FeTi)O_3$, of crystal system, No. 3, and sp. gr. 4·5 to 5·1. The deposit at Egerdund (south of Stavanger) is stated to have the composition $Fe(Mg)TiO_3,10Fe_2O_3$. Large deposits occur in Canada and the Travancore State, while that found in Johore (Malay Peninsula) contains 46·5 per cent. titanium oxide. (See V. S. Swanimathan (*B.C.A.*, 1931, A, 1145) and Titanium.)

IMIDES—Anhydrides of certain acids in which the oxygen atom is replaced by the divalent imido-group (: NH).

Succinimide $[(C_2H_4(CO)_2NH)]$ is a crystalline substance formed by heating ammonium-hydrogen succinate. The ortho-phthalimide $(C_6H_4(CO)_2NH)$ is a white crystalline body, of m.p. 233·5° C., used in the production of indigo, and made by dissolving phthalic anhydride in ammonia, evaporation to dryness, and fusion of the residue. (See Amides and Amines.)

IMIDO (IMINO) GROUP—The divalent group (: NH). (See Imides.)

IMPERMEABLE—Fabrics rendered waterproof by various processes are described as impermeable. Stone surfaces can be rendered more or less impermeable, and thus secured to some extent against atmospheric attack, by washing over with sodium silicate or silicon ester, and varnishes give impermeability to the surfaces of various articles. (See Stone Preservation.)

IMPORT DUTIES ACT—See *Ind. Chem.*, 1932, viii., 103.

INCANDESCENCE—A state of heat at which a substance begins to give out light or to glow. The wires of electric lamps and the mantles used for intensifying gas flames are incandescent when in use. Platinum commences to be visible when heated to 390° C., and as the heat is raised the incandescence increases. The blackening of carbon filament lamps has been attributed to sublimation of the carbon in a crystalline state. (See W. J. Bartlett on "Chemistry in Incandescent Lamp Manufacture" (*Ind. Eng. Chem.*, 1929, **21,** 970).)

INCHI-GRASS OIL (from *Cympopogan Cæsius*)—Yield stated to be 0·8 per cent.; sap. v. 5·6 and acet. v. 120. As found in commerce it contains somewhat varying proportions of borneol, camphene, limonene,

INCHI-GRASS OIL (*Continued*)—

and terpineol, and can be used as a substitute for palmarosa oil, which it resembles in odour.

INCINERATION—The process of reduction to ashes by burning or ignition. (See Destructors and Waste.)

INDAMINES—A group of dyestuffs obtained from the indo-anilines by substitution of the group —NH_2 for the quinone oxygen—for example, "phenylene blue" or indamine ($NH_2.C_6H_4.N : C_6H_4 : NH$).

INDANTHRENE (Blue)—A pigment dye, very fast and stable, of which eight varieties are made in this country; usually made by alkaline fusion of 2-amino-anthraquinone. For description of processes see Raffaele Sansone (*C.T.J.*, 1925, **76**, 261).

INDENE (C_9H_8)—A clear, heavy, mobile liquid, of b.p. 182° C., contained in that fraction of crude benzol which comes over at from 176° to 182° C. It rapidly absorbs oxygen from the air, and by exposure to air and sunlight forms polymerides. When heated to 190° to 200° C., it is quickly transformed into a resinous mass of polymerized resultants. (See Coumarone and Gums and Resins (Synthetic).)

INDIAN HEMP—See Hempseed Oil.

INDIAN INK (Chinese Ink)—See Inks.

"INDIAN OIL"—A proprietary, quick-drying, white spirit distilled from crude mineral oil; of sp. gr. 800, and with closed flash-point over 80° F., advocated as a solvent and turpentine substitute.

INDIAN RED—Some varieties consist of nearly pure ferric oxide (Fe_2O_3), but the natural pigment from the Persian Gulf contains ferric silicate ($Fe_2O_3SiO_2$). Imitations of the natural oxides are prepared by the action of acids on iron and precipitation of hydroxides or carbonates from the solution, followed by calcination.

INDIA-RUBBER (Caoutchouc)—See Rubber.

INDICAN (Indoxylglucoside) ($C_{14}H_{17}O_6N.OH_2$)—The active principle of the indigo plant, from which indigo blue is obtained. It can be obtained in a crystalline form in combination with 3 molecules of water, and is of the character of a glucoside, being resolved by hydrolysis into indoxyl and a glucose-like body named indiglucin (tetramethyl glucose):

$$\underset{\text{Indican.}}{C_{14}H_{17}O_6N} + OH_2 = \underset{\text{Indoxyl.}}{C_8H_7ON} + \underset{\text{Indiglucin.}}{C_6H_{12}O_6}.$$

In the pure state indican is a colourless substance, and by treatment with acids or by the action of enzymes is split up as shown by the above equation, and the resulting indoxyl is easily oxidized into indigo: $2C_8H_7ON + O = C_{16}H_{12}O_2N_2OH_2$. (See "Synthesis of Indican," by A. Robertson (*J.C.S.*, 1927, p. 1937); also Indigo.)

INDICATORS—See Hydrogen-ion Determination, Volumetric Analyses, Litmus, and Turmeric Paper.

INDIGO or INDIGOTIN—The formula $C_{16}H_{10}N_2O_2$ is supported by its vapour density, while the formula $C_{16}H_{12}N_2O_2$ is given as that of indigo-white. Indigo is a blue colouring matter, being an indigoid vat dyestuff, prepared from the herbaceous shrubs *Isatis tinctoria* (N.O. Leguminosæ), *Polygonum tinctoria,* and other plants, and formed from indican, which exists in the juice. *Indigofera leptostachya,* cultivated in Java and indigenous in Natal, is reported to be superior to *Indigofera tinctoria,* and even better results are credited to *Indigofera erecta.* Well-made samples are said to contain 70 per cent. of the glucoside associated with other substances (known as "indirubin," and "indigo brown"), which have an influence in the dye-vat, and which probably accounts for the alleged superiority of natural indigo over manufactured indigo, which is made synthetically from naphthalene or phthalic acid.

In the synthetic production of indigo, starting with naphthalene, it is first of all oxidized to phthalic acid, and this by sublimation is converted into phthalic anhydride ($C_6H_4(CO)_2O$), which when heated in presence of ammonia yields phthalimide ($C_6H_4(CO)_2NH$), and this compound, when subjected to the action of alkalies and an alkaline hypochlorite, produces anthranilic acid ($C_6H_4.NH_2.CO_2H$). By interaction with monochloracetic acid, anthranilic acid gives phenyl-glycine-ortho-carboxylic acid, and this when melted with an alkali and made into solution is oxidized by a current of air, thereby producing indigo blue (indigotin).

Another process consists in treating aniline with chloracetic acid, thus producing the phenol-glycine ($C_6H_5.NH.CH_2.COOH$), which when heated with sodamide (NH_2Na), or metallic sodium in the presence of ammonia, yields indigo blue through oxidation of the intermediate compound (indoxyl) ($C_6H_4.NH.C(OH).CH$). For an account of the manufacture of indigo as carried out at the Monthey works in Switzerland, see *Ind. Chem.,* 1926, ii., 557. Indigo can also be synthesized from fumaric acid and aniline. A further process (Lepetit's), stated to be used by Du Pont de Nemours and Co., consists in treating aniline with formaldehyde and sodium bisulphite, and then treating the product of that reaction with sodium cyanide, forming phenyl-glycine nitrile, which is subsequently fused with alkali hydroxide. (See R. Lepetit, B.C.A., 1926, B, 121.) Five different varieties of indigo are now made in this country.

The Indian cultivation of indigo has fallen off very much in recent years on account of its synthetic production, the acreage under production (which had exceeded one and a half million in 1896-97) being under 102,000 in 1924-25, and yielding about 19,100 cwt., whereas the acreage under cultivation in 1916-17 had risen to 750,000 and produced nearly 5,000 tons of indigo. The crop in British India 1926-27 has been estimated at 100,400 acres, and the yield of dye at 20,100 cwt.

The indigo plant is cultivated in Southern Nigeria, and yields a supply containing 56 per cent. indican when treated as in India.

Indigo sublimes at 300° C., and is insoluble in water, but soluble in aniline, glacial acetic acid, nitro-benzene, and chloroform, and dissolves

INDIGO (*Continued*)—
in hot strong sulphuric acid to a deep blue colour; it is this solution of indigo-sulphuric acid that is used in dyeing. By oxidation with nitric acid indigo yields isatin.

Natural **Indigo Blue** is prepared by cutting the plants just before flowering and steeping in water for twelve or more hours, when a fermentation takes place, yielding a yellow-coloured liquor, which is then drawn off, and subsequently agitated in contact with the air, in which process oxygen is absorbed and the indigo is thrown down as a greenish-blue precipitate. This is strained off, pressed, dried, and cut up into the cakes of commerce, and can be protected against bacterial changes even in hot climates by the incorporation of a small addition (0·05 per cent.) of paranitraniline.

China is the largest consumer of indigo, and a considerable amount of indigo is now produced in Manchuria. (See "The Hydrolysis of Acetylindoxylic Acid," etc., by G. Spencer (*J.S.C.I.*, 1931, **50,** 63 T); Indican, Isatin, and Woad.)

Indigo Carmine, or soluble indigo, prepared by treating a sulphuric acid solution of indigo with soda, is a blue powder soluble in water and used in dyeing.

Indigo White, the leuco-compound ($C_{16}H_{12}O_2N_2$), is a white, crystalline powder obtained from indigo by processes of reduction, including the use of ferrous sulphate and caustic soda, or grape sugar and soda or hydrogenation at from 50° to 60° C. in presence of a reduced nickel catalyst, and with the addition of sodium hydroxide. It is used in dyeing, by making use of processes which are capable of reconverting it into indigo blue on contact with the fabrics.

Indigo Yellow—See T. Posner and R. Hofmeister (*B.C.A.*, 1926, A, 1156).

INDIGO COPPER—See Copper Sulphides.

"INDIGOSOL O"—A product described as a stable sulphonic-acid ester salt produced from indigo-white, which can be applied to the fibre in dyeing operations in exactly the same easy manner as indigo extract. It is completely soluble in water, and all kinds of wool, woollen yarn, and woollen materials are more easily dyed than in the vat.

INDIUM (In) **and its Compounds**—Atomic weight, 114·8; sp. gr., about 7·12; m.p. 155° C.; with alleged isotope of mass number 115. A rare element so named on account of the two lines it exhibits in the indigo-blue part of the spectrum; analogous to aluminium, and occurring in many zinc-blendes. It is a ductile, soft, silver-white metal, easily soluble in acids, and forms alloys with lead and thallium; its compounds give a violet tinge to the Bunsen flame. The metal resembles aluminium in forming alums, and the halogen salts are soluble in water. There are two oxides (InO and In_2O_3); a yellow sulphide (In_2S_3); a hydroxide ($In(OH)_3$); two chlorides (InCl and $InCl_2$); a bromide ($InBr_3$); iodide (InI_3); nitrate ($In(NO_3)_6,9H_2O$); sulphate ($In(SO_4)_3$), etc. (See Thiel and Luckmann, *B.C.A.*, 1928, A, 852.)

INDOLE or BENZO-PYRROLE (C_8H_7N or $C_6H_4(CH.NH)CH$) is regarded as the parent substance of indigo, and is stated to occur in the essential oil of jasmine flowers. It is a feebly basic body of fæcal-like odour, soluble in alcohol, ether, and hot water; yields indigo when oxidized with ozone, and is used in perfumery. Both indican and indole at times result from protein decomposition in the bowels of man and other mammals.

INDOPHENOLS—A group of dyestuffs of phenolic character.

INDUCED REACTIONS—See Chemical Interactions.

INDUCTION (Inductance)—The power exhibited by a body of inducing a corresponding state in another body, as when a rotating magnet acts in the dynamo. (See Electricity.)

INDUCTION COILS—Apparatus for inducing electrical currents of high electro-motive intensity, made of a soft iron core surrounded by coils of insulated wires (primary and secondary), a condenser constructed of alternating layers of tin-foil and paraffin waxed paper, together with a means of interrupting the current in the primary, and thus producing induced currents in the secondary coil. These coils, when coupled up with some Grove's or Bunsen's cells, are capable of sending sparks across air spaces. (See Electricity and Ozone (p. 657).)

INDULINES—A group of dyestuffs.

INDUSTRIAL ALCOHOL—See Alcohol (Ethyl).

INDUSTRIAL DISEASES—See Diseases (Industrial) and Poisons.

INDUSTRIAL SAFETY—See R. Brightman on the "Position of the Chemist" (*Ind. Chem.*, 1930, vi., 317); on "The Place of Vocational Selection" (*Ibid.*, 1930, vi., 367); Occupational Matters and Poisons.

INDUSTRY (THE HUMAN FACTOR IN)—See T. H. Pear's address (*J.S.C.I.*, 1929, **48**, 227 T).

INFLAMMABILITY—See Dust and Dust Explosions, Flame, Flash-point, and Ignition.

INFUSION—An extract prepared by steeping or digesting vegetable substances or parts of plants in a solvent liquid with or without heating; sometimes effected by percolation.

INFUSORIAL EARTH—A light-coloured siliceous deposit found near Ebsdorf, also in the United States and elsewhere, is known by this name, but it is also applied to other deposits such as kieselgühr and diatomite, used as absorbents and for polishing purposes. (See Diatomite, Kieselgühr, and Tripoli.)

INKS—Liquids or pigments used for writing or printing, those for writing being made of various colours—black, blue, green, and red.

Black Ink is a mixture of an infusion of gall nuts with ferrous sulphate and a certain proportion of hydrochloric acid, also of gum arabic dissolved in the mixture to give body and gloss to the ink. Sometimes logwood and indigo carmine are added, and there are many recipes for its preparation.

Ordinary writing-ink stains can often be removed by alternate appli-

INKS (*Continued*)—

cations of a dilute solution of oxalic acid and that of bleaching powder. Some red ink stains can be removed by use of perborate solutions.

Blue Ink can be prepared by dissolving Prussian blue in a dilute solution of oxalic acid.

Condensation products of formaldehyde with phenols and their esters, which give a deep blue coloration with iron salts, are also used for making inks which have the advantage over iron gallate inks in that they do not favour the formation of rust, etc.

Red Inks are prepared from cochineal or Brazil-wood, or by dissolving carmine in ammonia solution.

Indelible Ink is prepared, amongst other methods, by mixing ordinary ink with Indian ink or lamp-black rubbed up with weak hydrochloric acid.

Copying Ink is prepared from logwood extract dissolved in vinegar and water, to which certain quantities of copper sulphate, alum, gum or glycerine, and sugar are added.

The formula adopted by the United States Government is as follows:

Tannic acid	46·8 grammes.
Gallic acid	15·4 ,,
Ferrous sulphate	60·0 ,,
Gum arabic	10·0 ,,
Dilute hydrochloric acid (U.S.P.) ..	50·0 ,,
Phenol	1·0 ,,
Suitable blue dye	4·4 ,,

and water to make up to 1,000 c.c. at 15·6° C.

The British Government's specification for inks requires a minimum of 0·2 per cent. iron for a fountain-pen ink and 0·5 per cent. for a standard ink for record purposes.

Copying Pencils are compounded of graphite, China clay, and some such dye as methyl violet.

Cancelling Inks must contain pigment and dyes of such character as to penetrate the fibre of paper so that the mark cannot be removed. They vary in composition, but lamp-black is often used in conjunction with a coal-tar dye and some non-drying oil.

Sympathetic Inks—The use of cobalt salts in the preparation of these inks is referred to under Cobalt Compounds, and resort is made to many other substances. For example, milk, orange or lemon juice, and dilute sulphuric acid can be used on unglazed paper for writing which remains invisible until heat is applied, when it becomes permanent. Saliva writing has been also resorted to for conveying secret information. Messages written with a dilute solution of copper chloride become visible whenever the paper is warmed, while solutions of some lead salts, such as the subacetate, can be used and made evident by exposure of the paper to the vapour of sulphuretted hydrogen. If the paper be glazed, the pen must not be pointed, as it is liable to scratch away the glaze, thus rendering the scratches detectable either by a microscope or

INKS (*Continued*)—

swabbing the surface with ink and then rubbing it off, the ink being absorbed by the unglazed portions.

When a strong solution of nitre is used for writing on paper, the writing must begin at a pre-arranged spot near the edge, and must be continuous, the application of a red-hot pin momentarily applied to the beginning of the writing causing a char, which runs right through the message.

The action of ink in developing writing made with lemon-juice or saliva is partly physical, as already explained, and partly chemical, increased absorption of pigment being one of the features, and acceleration of the oxidation of the ink being another feature.

Marking Ink usually consists of silver nitrate solution coloured and thickened with gum, but many others consist of cresol and dyes of the aniline class.

Printing Inks are made by incorporation of pigment with a suitable varnish medium and such other dryers and accessories as may be appropriate to their special applications. They are of great variety and of different materials, typographic inks being used for catalogues, book printing, etc., and made thinner and softer than lithographic inks (which must be unaffected by water), and special ones again being made for the higher quality of depressed surface printing. In the past they were made chiefly from lamp-black and linseed oil, soap and resin being sometimes incorporated; but lamp-black having become too expensive, it has been displaced by the use of resin black, soot, "shale," or other forms of carbon admixed with mineral matters and colouring matters such as aniline colours, or chromium, iron, or manganese compounds; while linseed and castor oils have also been largely displaced by tar oils and mineral oils.

For good and medium qualities, however, polymerized or boiled linseed oil is still used, together with resin oil, soap or resin soap, and various pigments. Bitumen, asphalt, or stearin pitch are also used in admixture in some inks, particularly those used for rotary press work, as they improve the covering property and prevent the ink piercing the paper. For news-press work carbon black as produced by the incomplete combustion of natural gas is used because it has great tinctorial strength, but in order to prevent any brownish undertone in the thin film of ink used, a little bluish dye is added to correct the colour and intensify the effect; mineral oil and resin being the usual blend employed, the whole being mixed and finally ground. Further details of various printing inks are given by E. S. Hanes in the "Printing Issue" of *The Times*, October 29, 1929, and L. M. Larsen (*Analyst*, 1931, **56,** 64).

"Sulphite" waste liquor is used in Sweden as a thickening agent for printing inks, and genuine "quicksilver vermilion" is used in the manufacture of red printing ink. (See N. F. Budgen on "Printing Ink Technology" in *C.T.J.*, 1925, **76,** 99, and *Chem. and Ind.*, 1928, **47,** 1147.)

INKS (*Continued*)—

Typewriting Inks are intermediate between writing and printing inks, aniline dyes being often employed in conjunction with the other materials, which sometimes include a proportion of glycerine.

Chinese Ink is made from vegetable charcoal prepared from rice straw or vegetable oils and other suitable materials.

Indian Ink is a black powder imported from China, made from carbon prepared by burning camphor, cemented with gelatin or glue.

Invisible Ink—See paper by H. T. F. Rhodes on "The Scientific Examination of an Historic Document," dealing with the inks used in preparing and making some part illegible (*Chem. and Ind.*, 1931, **50,** 303); O. Mezger (with others) on "Ink Tests" (*B.C.A.*, 1931, B, 1061); C. Ainsworth Mitchell (*Analyst*, 1920, **45,** 247, and 1932, **57,** 144); *Inks,* by C. Ainsworth Mitchell, third edition (Chas. Griffin and Co., London); *Ink Manufacture,* by S. Lehner (Scott, Greenwood and Son, London); and Sympathetic Inks.

INORGANIC CHEMISTRY—The term "inorganic" is applied to all substances that do not contain carbon as a constituent, also to some few others in which carbon is present in an unimportant sense, such as the metallic carbonates. The natural rocks and earths, the metals and minerals, are all inorganic bodies. (See Textbook by G. S. Newth, 1926 (Longmans), and A. F. Holleman (Chapman and Hall); *Applied Inorganic Analysis,* with special reference to metals, minerals, and rocks, by Hillebrand and Lundall (Chapman and Hall); *Manual of Chemical Analysis* (*Qualitative and Quantitative*), by G. S. Newth (Longmans); *The Quantitative Analysis of Inorganic Materials,* by N. Hackney (C. Griffin and Co., 1930); *Technical Chemists' Handbook: Tables and Methods of Analysis for Manufacturers of Inorganic Products,* by G. Lunge, third edition, revised by A. C. Cumming (Gurney and Jackson); *Elementary Inorganic Chemistry*, by J. W. Mellor (1930) (Longmans); *Intermediate Inorganic Chemistry,* by J. W. Mellor (Longmans); *A Textbook of Inorganic Chemistry,* by J. R. Partington (Macmillan and Co.); and *Inorganic Chemistry*, by T. M. Lowry (Macmillan and Co.).)

INOSITE (**Inositol**) $(C_6H_{12}O_6)2H_2O$—A crystalline sugar-like substance found in the muscles of the heart and in certain other animal tissues. It loses its water of crystallization at 100° C., and is not susceptible to alcoholic fermentation. (See Vitamins.)

INSECTICIDES and FUNGICIDES—These various agents have to be used with discretion according to the known habits of the pests to be destroyed and with due regard to safety of the plants, etc., affected by them. Some insecticides kill by the poison that is absorbed internally, but in other cases in which the insects suck their food from the liquid contents of plants so-called "contact poisons" have to be employed, the lethal action being by absorption through their bodies. They are for the most part used in spray form. Many phenolic, carbolic, and

INSECTICIDES (*Continued*)—

creosotic preparations, such as "okol," "izal," "cyllin," "creoleum," "carbolineum," etc., can be employed for general use when appropriately diluted; stronger mixtures being required when used as fungicides than when used as insecticides. Sodium fluosilicate mixed with slaked lime and distributed in dust form can be used in place of arsenical preparations in the control of various insect pests, including boll-weevil. The ordinary arsenical weed-killers are made by dissolving proportions of arsenious oxide in sodium hydrate solution.

Naphthalene and carbon disulphide are often used for the destruction or removal of the turnip gall, weevil, wireworms, the larvæ of various beetles, the leather-jacket, the cabbage-root fly, carrot fly, mangold fly, and onion fly in the soil. A spray of lead arsenate is used for the destruction of fungoid growths and various kinds of moths on trees, and hydrocyanic acid (applied by way of fumigation) in respect of red spiders and certain fly pests in glass-houses. (See Fumigation.)

Calcium arsenite and arsenate are used for the destruction of the leaf-worm and boll-weevil on growing cotton plants.

Sulphate of copper solution is employed for ridding wheat and barley of smut, and very dilute formaldehyde solution is said to be even better because it does not interfere with the germinating power of the seed.

Copper sulphate in dilute solution can be used as a spray for mildews and insect pests on fruit trees and potatoes.

Bordeaux mixture, as described under that heading, is used as therein noted in viniculture, for protecting potatoes from blight by spraying the haulms and leaves, and in respect of apple and pear trees.

Nicotine preparations, including "dusts" made by impregnating kaolin, lime dust, and other minerals with nicotine sulphate, are largely used, some preference being shown to the employment of powdered magnesium limestone (dolomite) as the carrier, and when finely powdered sulphur is incorporated in the mixtures, the dust is effective against mildew and other fungi. Soap emulsions containing nicotine are also used. Pyridine and some of its derivates are employed by virtue of their high toxicity to certain plant lice. According to a recent report, powdered zinc carbonate, magnesium oxide, and magnesium carbonate are effective dust poisons for the corn beetle and certain other parasites. Aluminium sulphate in admixture with other ingredients, such as lime, sulphur, calcium arsenate, and nicotine, has been recommended for use in spray form in orchards.

Mixtures of copper salts of sulphonated, pitchy, or resinous material, and either sulphur or its compounds or arsenical compounds are used; while mixtures containing sulphur can be employed for the simultaneous destruction of *Peronospera* and *Oidium* on vines.

Mercury salts of similar sulphonic acids exhibit a very strong fungicidal action on spores of *Filletia tritici*.

"Creoleum" and "carbolineum" are useful for destroying fungoid pests on trees, or can be used by banding; while a sulphur product named "Solbar," in common with lime-sulphur washes, is useful for ridding

INSECTICIDES (*Continued*)—

trees of winter fungous pests, such as the common fruit scab, *Fusicladium*, the apple and gooseberry mildews, etc.

"Sanitas" fluid has been recommended in diluted form for the destruction of aphides and caterpillars on trees and for application by spray in frames and conservatories.

Liver of sulphur is used as an insecticide and fungicide, also many other chemicals and mixtures as referred to under their respective headings, whilst the sterilization of soils is described under the heading of Soils.

For destruction of weeds on paths, arsenical preparations are often recommended, but "creocide" and other creosotic articles, which are miscible with water, are safer, more economical, and equally effective.

Warble infection in cattle can be effectually dealt with by a wash made by soaking 4 lbs. of tobacco dust in lime-water prepared by adding 1 lb. of quicklime to the gallon.

It has been reported by M. Lindet that soil treated with 10 to 12 per cent. sulphuric acid is freed from weeds and noxious insects, and calcium chlorate is said to exercise a marked destructive action on weed-infested areas.

Bugs and other insects are best dealt with by fumigation with formaldehyde or by the use of sulphur candles.

As an insecticide in respect of insects which infest stored grain, the non-inflammable gas evolved from a mixture of 2 volumes ethyl acetate and 1 volume of carbon tetrachloride has been found satisfactory.

A general indication of work done on the subject makes it appear that calcium caseinate is a useful ingredient of insecticides owing to its property of reducing their surface tension, thus increasing their wetting and penetrating power, the efficiency of some washes being increased, it is stated, by as much as 100 per cent. by the addition of 0·2 per cent. of the caseinate. (See Calcium Caseinate, p. 128.)

Winter washes for fruit and other trees are mainly directed against the eggs of insects, the older ones employed being made up chiefly of caustic soda or lime and sulphur, but coal-tar preparations have supplanted their use to a large extent, while a solution of dinitrocresol has proved particularly effective when used to the extent of from about ½ to 1 ounce for each large fruit tree.

Summer washes are not required to be of such great penetrating action and include a number of substances, some of which act by contact action, and others as stomach poisons; but they must be harmless to the young leaves. Nicotine is most generally employed, but pyrethrum and "Derris" preparations are also highly effective. (Derris root (*Derris elliptica*), one of the *Leguminosæ* growing in the Straits Settlements and other tropical areas (containing a number of resinous substances which are insoluble in water, but make a milky emulsion when steeped therein) of which the active principle appears to be a crystalline substance named rotenone.) It is a very powerful insecticide, devoid of injurious effects on the foliage and blossoms of plants, and is the source of dusting-powder and other preparations,

INSECTICIDES (*Continued*)—

advocated as more or less non-poisonous. The pure poison from pyrethrum used in the proportion of 1 ounce to the ton of water is stated to be fatal to many insects. Cevadilla (Sabadilla) and cevadine also exhibit appreciable insecticidal power. (See Derris Root and Veratrine.)

References: The fungicidal properties of certain spray fluids in respect of hop mildew by Goodwin, Martin, and Salmon (*B.C.A.*, 1926, B, 506); articles on "Insecticides" (*C.T.J.*, 1926, **78**, 251, 481, and 579); two American papers by C. M. Smith and R. N. Chipman respectively (*Chem. and Ind.*, 1925, **44**, 417 and 421); "Contact Insecticides," by Tattersfield and Gimingham (*J.S.C.I.*, 1927, **46**, 368 T); "Fluorine Insecticides" (*C.T.J.*, 1929, **85**, 126); F. Tutin on "Tar Distillate Washes for Insecticidal Use" (*Gas J.*, September 19, 1930); *C.T.J.*, 1931, **88**, 32, on Derris Root Insecticides in combating the warble fly pest, etc.; "The Examination of Tar and Mineral Oil Insecticides," by H. Martin (*J.S.C.I.*, 1931, **50**, 91 T); "The Chemical Control of Insect Pests," by R. Brightman (*Ind. Chem.*, 1931, vii., 289); on the "Spraying of Plants," by R. M. Woodman (*J.S.C.I.*, 1931, **50**, 391 T); Reports for 1927 and 1928 of the Rothamsted Research Station, Harpenden, and *Agricultural Research in 1929* (John Murray, London) concerning Fruit Tree Insecticides, of which an account will be found (*C.T.J.*, 1931, **88**, 27); and *Insecticides, Fungicides, and Weed Killers,* by E. Bourcart, translated by T. R. Burton Scott (Greenwood and Son); see also Dry-Rot, Fumigation, Fungi, Hops, Insect Powder, Moth-Proofers, Nicotine, and Pyretol.

INSECT POWDER (Pyrethrum Powder)—The dried unexpanded heads of various species of *Pyrethrum*, including *P. cinerariæ folium, P. carnium,* and *P. roseum* (N.O. Compositæ). The ground Montenegrin or Dalmatian variety is the best, the insecticidal properties being variously attributed to its essential oil and pyrethrotoxic acid. Again, it has been stated that the insecticidal action of pyrethrum flowers is due neither to an alkaloid nor a glucoside, but to an oleo-resin, being a readily saponifiable ester, the liberated acid of which is also active to a less extent. This ester, which is harmless to man, but poisonous to cold-blooded animals, can be abstracted from the flowers or the whole plant by cold alcohol. Analytical results show that the ether extract of Dalmatian insecticide from the flowers alone and flowers and stem together varies from 2·90 to 5·8 per cent., the larger proportions being in the flowers.

Pyrethrum insecticides are stated to kill or paralyze by contact, but quickly lose this toxic character upon exposure to the air.

The water-soluble extract in the dried material is about 22 to 25 per cent. The chief adulterant is the ground stem of the plant.

Later information concerning the value and determination of pyrethrin i. and ii. as contained in *Pyrethrum cinerariæ folium,* and regarded as the active principles, is given by Tattersfield and Hobson (*J. Agric. Sci.*, 1929, **19**, 266 and 433).

Gnadinger and Corl have determined the relative toxicity of these

INSECT POWDER (*Continued*)—two pyrethrins i. ($C_{21}H_{30}O_3$) and ii. ($C_{22}H_{30}O_5$), and state that ii. has a toxicity of at least 77 per cent. of No. i. (*J. Amer. Chem. Soc.*, 1930, **50**, 3300). See also Tattersfield and Hobson (*B.C.A.*, 1929, B, 732); Gnadinger and Corl (*Ibid.*, p. 996); Gulland and Hopton (*J.C.S.*, 1930, pp. 6-11; *Analyst*, 1929, **54**, 754); *C.T.J.*, 1930, **87**, 427, on the Development and Status of the Japanese Industry concerning Pyrethrum Insecticides; and Insecticides.

INSULATING MATERIALS—Electrical insulating materials used for various applications include "glass silk," rubber, ebonite, "bakelite," and other synthetic resins, bitumen, shellac, certain waxes, cellulose alone or after treatment with zinc chloride, millboards, laminated paper boards, varnishes, oils, porcelain, marble, slate, etc. Colloidal materials as a class exhibit a high mechanical resistance to ionic "migration." See W. H. Nuttall (*Chem. and Ind.*, 1928, **47**, 1359).

INSULATION (ELECTRICAL)—See Electricity.

INSULATION (HEAT)—See N. H. Chamberlain (*J.S.C.I.*, 1932, **51**, 89 T), Heat, and Refrigeration.

INSULIN—A hormone (known by its effects) contained in the human pancreas and that of the ox and pig (from both of which it is prepared): of value as an anti-diabetic remedy, causing storage of glycogen to some extent on the one hand and the disappearance of some of the sugar contained in the blood by oxidation on the other hand, thus maintaining a satisfactory adjustment. (See Thyroxin.) It is obtainable also from the islet tissue of codfish, acorns, and some similar substance from yeast. According to one account (*J.C.S. Abs.*, I., cxxvi., 1387), two hormones are distinguished, one concerned with the oxidation of sugar into carbon dioxide and water, and the other polymerizing sugar to glycogen. It is obtained from the pancreas by means of alcohol acidified with hydrochloric acid, protein material being associated with the active extract. Among methods for preparing this substance is that of Dodds and Dickens (*Lancet*, 1924, I., 330), in which the macerated pancreas is extracted with aqueous formic acid, picric acid added to the extract, and the "insulin picrate" subjected to extraction with acetone and then treated by Dudley's method (*Biochem. J.*, 1923, **17**, 376). A crystalline form of the substance first isolated by Abel can be prepared by several modifications of his process, and is now regarded as the active principle of the gland. In any case, it is stated to be necessary in course of its extraction to prevent the proteolytic action of enzymes on the pancreas. Methods for its determination are based upon its physiological action, but biochemical methods are also available (see *Analyst*, 1925, **50**, 570). A unit dose of the watery solution as prepared for sale enables a patient to take at the ensuing meal 1·4 grms. of additional carbohydrate or its equivalent without excreting sugar.

The theory is that the sugar glucose before it can be utilized as a food must be first of all converted into an active form known as gamma-

INSULIN (*Continued*)—

glucose, and that this is effected by insulin and then assimilated. When this active principle is absent (as in diabetes) from the pancreas secretion, it can be replaced by the preparation made from the other sources.

Insulin sulphate has been described as having the percentic composition: C, 47·73; H, 7·27; N, 14·53; S, 1·73; O, 22·84; H_2SO_4, 5·90; representing a polypeptide with about fifteen constituent amino-acids (*J.C.S. Abs.*, I., 1924, p. 1271). A method for the extraction and purification of insulin is given by L. Banti (*J.S.C.I.*, 1924, B, 1028). C. Funk has from analytical data suggested the formula of insulin as $C_{69}H_{102}O_{22}N_{18}S$ or $C_{74}H_{114}O_{24}N_{20}S$ (*B.C.A.*, 1926, A, 1063), while J. J. Abel and others have given the simplest formula as $C_{45}H_{69}O_{14}N_{11}S_13H_2O$, the water being lost at 105° to 120° C. (*B.C.A.*, 1927, A, 701). (See also Dickins, Todd, Lawson, and Maclagen (*Chem. and Ind.*, 1927, **46**, 1297); A. Renshaw (*J.S.C.I.*, 1925, **44**, 95 T); F. H. Carr (*Chem. and Ind.*, 1926, **45**, 750, and 1927, **46**, 183); Jensen and others (*B.C.A.*, 1929, A, 851); Harrington and Scott (*Ibid.*); J. G. Fitzgerald (*Chem. and Ind.*, 1932, **51**, 143); and Culhane and Greenwood (*Chem. and Ind.*, 1932, **51**, 259); Hormones and Intarvin.)

INTARVIN—The name of an alleged new remedy for diabetes, said to be a true oleo-margarine made from margaric acid and being essentially glyceryl margarate; creamy-white, odourless, and tasteless, melting at body heat, and quite palatable. (See Margaric Acid.)

INTENSIVE DRYING—See Heat.

INTERACTIONS—See Chemical Interactions.

INTERFACIAL TENSION—An interface is the boundary surface between two phases, and, according to Reynolds, the interfacial tension between two liquids is the difference between the surface tension of the one saturated with the other and the surface tension of the other saturated with the one. The measurements are effected by the drop-weight and capillary tube methods, the former giving results 78·8 per cent. of those found by the latter. The interfacial tensions of pure liquids in contact with water are constant at one temperature, and are the less the greater their mutual solubility. (See "Chemistry at Interfaces," by W. Hardy (*J.C.S.*, 1925, cxxvii., 1207); Colloids and Lubricants.)

INTERMEDIATES—A general term for some hundreds of derivatives obtained from anthracene, benzene, cresols, naphthalene, phenol, toluene, and other direct coal-tar products, mostly colourless, but all of which are used in the manufacture of synthetic dyes. They include H acid, aniline oil, dinitrochloro-benzene, dinitrophenol, ortho- and para-chloraniline, naphthol (alpha and beta), parachlorphenol, paranitro-ortho-aminophenol, naphthylamines, phthalic anhydride, anthranilic acid, ortho-amino-benzoic acid, dimethylaniline, nitro-benzene, paranitraniline, resorcin, salicylic acid, many aromatic aldehydes, and a large number of other compounds, many of which are described under

INTERMEDIATES (*Continued*)—
their respective names. (See *Intermediates*, by A. Davidson (Ernest Benn, Ltd., London); also Dyes and Acids.)

INTERSTELLAR MATTER—See Ether, Gravitation (p. 420), and Light (p. 538).

INTROFIERS—Substances that accelerate impregnation—that is, when added to impregnating media cause changes in their fluidity and specific wetting qualities. (See Wetters.)

INULIN or ALANT STARCH $(C_6H_{10}O_5)_x$—A carbohydrate contained in dahlia bulbs (*Dahlia variabilis*) to the extent of about 10 per cent. of the weight of the ripe tubers, and in smaller proportions in the roots of other members of the Compositæ, such as chicory and artichokes. According to Drew and Haworth (*J.C.S.*, 1928, p. 2690), it would appear to be a substituted variety of polymerized ethyleneoxide, consisting of chains of fructo-furanose or γ-fructose rings. An intermediate stage of its transformation into lævulose by hydrolysis is described by them. Pringsheim and Hensel state that the molecular weight of the acetate in freezing acetic acid at sufficient dilution, corresponds with that of a difructose anhydride acetate (*B.C.A.*, 1930, A, 896). See also Pringsheim (with others) (*B.C.A.*, 1930, A, 1562). Reilly and Donovan found that the molecular weight of inulin as determined by cryoscopy in acetamide agrees with that of a difructosan, and regard it as a co-ordinate complex of difructosan units (*B.C.A.*, 1930, A, 896). In the pure state it is a white, crystalline powder resembling starch, but, unlike that substance, it dissolves in aqueous sodium hydroxide and in hot water to a clear solution, and is not coloured blue by iodine. It is unaffected by diastase, and is not fermentable by yeast, but when boiled with water or dilute acid it is converted into a variety of fructose. It is used in the preparation of diabetic bread, and is a stronger sweetener than cane sugar.

"INVAR"—A nickel-steel alloy devoid of temperature co-efficient of expansions, so that surveying tapes made of it are almost unaffected by temperature; also used for making the pendulum rods of good clocks.

INVERSION—See Invertase and Walden's Inversion.

INVERTASE (Invertin, Zymase)—An enzyme present in ordinary yeast, which, apart from the yeast cells themselves, has the power of converting (inverting) cane sugar into glucose and fructose by hydrolysis to the reported extent of 200,000 times its own weight of cane sugar without then losing its effect $(C_{12}H_{22}O_{11} + H_2O = C_6H_{12}O_6 + C_6H_{12}O_6)$.

It is ordinarily prepared by macerating yeast which has been dried at room temperature (in order to break the cell walls) with water, and filtration of the extract, using an ordinary filter-paper, so as to retain the yeast cells thereon. It is stated to gradually decompose in aqueous solution, and to lose all its activity in course of about eighteen months, also to undergo a temporary loss of activity on drying. Invertase from honey is stated to exhibit some difference in character from that

INVERTASE (*Continued*)—obtained from yeast. (See P. E. Papadukis, *J. Biol. Chem.*, 1929, **83**, 561).

The hydrolysed product "invert sugar" is lævo-rotatory, whereas a solution of cane sugar is dextro-rotatory, the fructose being more strongly lævo-rotatory than the glucose is dextro-rotatory—an instance of inversion. Its commercial manufacture is carried out by gently boiling for some thirty minutes a mixture of 750 lbs. sucrose in 250 lbs. water and 10 ozs. of tartaric or 13 ozs. citric acid, the sugar being first dissolved in the water, and the acid (also dissolved in water) being added afterwards. The finished product should weigh 950 lbs. (S. Jordan).

INVERT SUGAR—The preparation of invert sugar by all processes depends upon the activity of an acid, salt, or enzyme in aqueous solution whereby the sucrose is hydrolysed, taking up a molecule of water, and being thus split up into dextrose (glucose) and lævulose (fructose).

Invert sugar is used in the preparation of infants' and invalid foods, as a source of lævulose and dextrose, and in the preparation of plug and other tobaccos. (See Invertase and Sugar.)

IODATES—See Iodine Compounds.

IODEOSIN—An indicator. (See Volumetric Analyses.)

IODIC ACID—See Iodine Compounds.

IODIDES—See Iodine Compounds, and *C.T.J.*, 1927, **81**, 180.

IODINE (I) **and its Compounds**—Atomic weight, 126·93, and a reputed isotope of mass number, 127; sp. gr., 4·95; m.p., 113·5° C. Iodine, in combination with potassium, sodium, magnesium, and calcium, is widely distributed in nature. It is also present in sea-water, sea-weeds (including the *phyllophoren* algæ of the Black Sea), and *caliche* or Chile saltpetre. (See Caliche.) It is prepared to some extent from kelp (ashes from sea-weeds), also from the soluble iodides found in many of the mineral springs of the Dutch East Indies and, to some extent, as a by-product in super-phosphate manufacture in Denmark, the iodine source being the phosphate rock employed. The main supply, however, is from the concentrated mother-liquor of the Chile saltpetre (which contains less than $\frac{1}{4}$ per cent.), and that of the Stassfurt salt deposits, from the iodate content of which it is precipitated by sodium bisulphite, and, after drying, purified by sublimation. In Russia, iodine is produced to some promising extent from the well-waters of the naphtha wells, which contain some 0·015 to 0·2 grm. per litre: there is also a considerable production in liquid form from natural sources in Soerabaya (Dutch Residency of Java). The total production of iodine in 1925 was 970 metric tons, of which Chile contributed 786, and in 1929 the Chile production was 1,387 metric tons. Japan contributes about 90 tons per annum. (See *C.T.J.*, 1926, **79**, 277; *C.T.J.*, 1927, **80**, 255; and 1931, **88**, 134.)

The sea-weeds which contain most iodine are of the so-called "drift"

IODINE (*Continued*)—

order—viz., *Laminaria digitata* and *L. stenophylla*, each of which has been stated to contain a little less than ½ per cent., and the ash of the root of *L. hyperborea* about 1 per cent., the stalks about 3 per cent., and that of the leaves about 4 per cent. iodine. The weeds of the White Sea and the Murman coast are rich in iodine content, while in Brittany in 1924, 72 tons were produced from sea-weeds.

A mixture of various Black Sea algæ contained 0·0859 to 0·172 per cent. iodine or 0·138 to 0·338 per cent. of the ash after combustion, while the corresponding figures for *Cystosieæ* are 0·095 and 0·146 per cent., and for *Phyllophora* 0·645 and 1·01 per cent. (Komareckyj, *B.C.A.*, 1929, p. 355). More recently the iodine contents of sea-weeds have been given as follows: *Fucus vesiculosus and nodosus*, 0·070 per cent.; *Fucus vesiculosus*, 0·013 per cent.; *Potwrack*, 0·050 per cent.; *Laminaria*, 0·175 per cent.; *Costaria*, 0·029 per cent.; *Alaria*, 0·027 per cent. (See F. Shuts' report, *Analyst*, 1930, **55**, 389); also Kelp and Seaweeds.)

Iodine organic products of therapeutical value are also made in France from the sea-weed *Laminaria flexicaulis*. (See Algin.)

Details of the manufacturing processes for obtaining iodine from Chile saltpetre and sea-weeds are given in G. S. Newth's *Textbook of Inorganic Chemistry* (Longmans and Co., 1926 issue, pp. 415-418).

Iodine is blue-black, of sp. gr. 4·95, easily obtained in crystalline form, and readily vaporizes, the vapour having a beautiful violet colour; it has a characteristic penetrating odour and is only slightly soluble in water, but readily soluble in a solution of potassium iodide, alcohol, carbon disulphide, chloroform, ether, etc. Even an extremely dilute solution of iodine gives with starch solution an intensely blue-coloured compound.

In general properties it strongly resembles its family neighbours, chlorine and bromine. Dilute solutions of it in water and alcohol are used in surgery for antiseptic purposes.

Iodine in combination with the alkaline metals forms iodides, the most valuable of which is potassium iodide (KI), which is produced in solution together with potassium iodate when iodine is dissolved in a warm solution of potassium hydroxide. Potassium iodide crystallizes in anhydrous cubes, is very soluble in water, and is extensively employed as a medicament in the treatment of goitre, etc., and in photography. It would appear to have some concern with nutrition of the human body, the thyroid gland being the mechanism controlling exchange, and some remarkable results have, it is stated, been achieved by the use of iodine for prevention of goitre.

Hydriodic Acid (HI) can be prepared in a variety of ways, and among others by exposing a mixture of hydrogen gas and iodine vapour to strongly heated platinum sponge; also by adding to 10 parts of iodine in an atmosphere of carbon dioxide, 1 part of phosphorus little by little slowly, and pouring upon the mixture 4 parts of water, when upon the application of gentle heat an abundance of hydriodic acid gas is generated free from iodine. The gas is colourless, pungent, and

IODINE (*Continued*)—

extremely soluble in water, a saturated solution having a sp. gr. of 1·67 at the ordinary temperature and pressure.

Iodic Acid (HIO_3) is a crystalline, white, solid body, soluble in water, prepared by action of sulphuric acid upon barium iodate. It forms iodates, such as potassium iodate (KIO_3), corresponding to potassium chlorate ($KClO_3$). Potassium iodate can be prepared from the iodide by heating with potassium chlorate at 350° to 400° C., oxygen being also evolved.

Periodic Acid ($HIO_4,2H_2O$ or H_5IO_6) is a white, dibasic, crystalline acid made by action of perchloric acid upon iodine; it melts at 133° C., is decomposed at 150° C., is soluble in water and alcohol, and used as an oxidizing agent. (See N. Rae, *J.C.S.*, 1931, p. 876.)

Iodine Pentoxide (I_2O_5) is a white, crystalline body, soluble in water, and when heated to 275° to 300° C. is split up into iodine and oxygen.

Iodine forms two compounds with chlorine—viz., iodine monochloride (ICl) and trichloride (ICl_3). Both these compounds are formed by passing dry chlorine gas over iodine, when it first of all melts to a dark reddish-brown colour, and subsequently solidifies to a mass of red crystals of ICl if care be taken not to use an excess of chlorine; but if more chlorine be used, then the yellow trichloride in crystalline form is produced.

Iodine Cyanide (ICN) is a colourless, crystalline substance of pungent odour, soluble in water, alcohol, and ether; used as a preservative by taxidermists.

IODINE VALUE or NUMBER (Fats and Oils)—See J. J. A. Wijs (*Analyst*, 1929, **54**, 12) and Fats, p. 337.

IODITE (Iodyrite)—Mineral silver iodide, of crystal system, No. 3, and sp. gr. 5·5. (See Silver.)

IODOFORM (CHI_3)—A yellow, crystalline substance prepared by warming alcohol with iodine and alkali, or by heating acetone or aldehyde with iodine in presence of an alkali. There is also an electrolytic process for its production, using a mixture of an aqueous solution of potassium iodide and alcohol in presence of potassium carbonate, carbon dioxide gas being meanwhile passed through. These processes are referred to in the *C.T.J.*, 1925, **77**, 158, and by A. Vyskŏcil (*B.C.A.*, 1929, A, 1021). It has been found that appreciable quantities of iodoform are produced by the action of iodine and caustic soda upon purified cotton and various celluloses.

It melts at 120° C., has a peculiar odour something like that of saffron, and is used as an antiseptic in the practice of surgery. Its unpleasant odour is removed by dissolving it in air-oxidized turpentine ("Sanitas" oil), without detracting from its surgical value. It is insoluble in water, but dissolves in both alcohol and ether.

"IONAMINES"—A class of dyestuffs, being insoluble azo compounds (which can be rendered soluble), of value for dyeing artificial acetate

“IONAMINES” (*Continued*)—

silk, etc. They fix themselves upon the fabric and leave the cotton white when used in respect of a mixture of the two materials. (See Dyes.)

IONIUM—A radio-active solid substance, possibly of an elemental character, obtained as a disintegration product from uranium minerals, giving a spectrum and exhibiting chemical properties identical with those of thorium. According to G. D. Kammer and A. Silverman, it can be extracted from high-grade carnotite (containing more than 15 per cent. uranium oxide) with hydrochloric acid, and it exists in average Colorado carnotite in the proportions of 1 : 15·8 thorium, which they regard as an isotype of ionium (*J.Amer.C.S.*, 1925, **47**, 2514-2522). Its atomic weight is stated as 230·5.

IONIZATION—(1) The charging of gaseous molecules so that the gas conducts an electric current. (2) Electrolytic ionization (dissociation), or assumed splitting up of electrolytes in solution into two parts (anions and cations). Atomic ionization is said to be effected by the action of light in chemical changes by the ejection of electrons. (See address by H. Hartley on the theory of electrolytic conduction (*Chem. and Ind.*, 1931, **50**, 807) and Electricity.)

IONOGENIC (**Ionizable**)—Subject to ionization, with production of ions.

IONONE ($C_{13}H_{20}O$)—An artificial essence of violet, made from citral and acetone: sp. gr. at 15° C. = 0·935 to 0·940; b.p. at 10 m.m., 126° to 128° C.; ref. ind. at 20°, 1·5035 to 1·5070; and opt. rot., 0°. There are several so-called ionones, one of which is the odoriferous principle of the iris root. (See Irone, Orris Oil and Perfumes.)

IONS—Electrified atoms or groups of atoms, produced by electrolytic dissociation of liquids or gases (as, for example, by the passage of X rays). A new method for the separation of rare earths has been developed by J. Kendall, based on the difference of mobility of ions. (See *Chem. and Ind.*, 1930, **49**, 894, and Ionization.)

IPECACUANHA—Used as an emetic, diaphoretic, and expectorant, consisting of a mixture of alkaloids prepared from the dried root of certain plants of the N.O. Cinchonaceæ growing in Brazil, Selangor, and Straits Settlements. It contains several active principles, including emetine and cephaline, which is related to emetine. The best plant is said to be the *Psychotria ipecacuanha* of Brazil and New Granada, the greater portion of the emetine being contained in the cortical part. Emetine is a white powder, variously represented as having the compositions $C_{30}H_{44}O_4N_2$, $C_{29}H_{40}O_4N_2$, and $C_{25}H_{28}(OMe)_4N_2$ (m.p. 68° C.; soluble in alcohol and ether), and cephaline as $C_{25}H_{28}(OMe)_3OH.N_2$ (m.p., 102° C.; soluble in alcohol). (See Brindley and Pyman (*J.C.S.*, 1927, p. 1067) and Späth and Leithe (*B.C.A.*, 1927, A, 471).)

The hydrochlorides of the alkaloids are used in dentistry and medicine, and the drug is used in compounding “Dover’s Powder.”

Emetine periodide is said to be the most effective and the least toxic of the various emetine medicaments for use in cases of amœbic dysentery.

IRIDIUM (Ir) **and its Compounds**—Atomic weight, 193; sp. gr., 22·41; m.p., 2,350° C. (crystal system, No. 1). A white, hard, brittle, and lustrous metal, occurring in alloy form with platinum and osmium, in several Uralian ores, and nearly related to those metals in its chemical characters. Two of these alloys are known as platin-iridium and osmiridium or iridosmine.

It is used in alloy with platinum for hardening, also in making fountain-pen points, magneto-points contacts, watch and compass bearings, and irido-platinum alloy for use in thermocouples, etc. In compact form, iridium is insoluble in acids, and it forms alloys with copper, gold, lead, and mercury. A number of compounds are known, including three oxides (one of which, known as "iridium black," is used as a pigment for china ware), three chlorides ($IrCl_2$, Ir_2Cl_6, $IrCl_4$), and iodides. The tetroxide is said to be produced by heating the hydroxide in nitrogen at 350° C. Its salts are soluble in water, and, in common with palladium, the metal has the property of absorbing gases by occlusion. (See Occlusion and Osmiridium.)

IRIDOSMINE—See Iridium and Osmiridium.

IRIS—See Perfumes.

IRISH MOSS (**Carrageen**)—The sun-dried (bleached) *Chondrus crispus*. (See *Analyst*, 1927, **52**, 265; and Sea-weeds.)

IRON (Ferrum, Fe) **and its Compounds**—Atomic weight, 55·84; sp. gr., 7·86; m.p., 1,530° C.; credited with two isotopes, 54 and 56. Iron occurs in nature in the form of pyrites and many other ores. Magnetic iron ore (*magnetite* or *loadstone*) (FeO, Fe_2O_3) is a crystalline compound of oxides of iron, from which much of the best Swedish iron is made. Red *hæmatite* (Fe_2O_3) (crystal system, No. 3, and sp. gr. 4·5 to 5·4) is largely mined in some parts of Lancashire, Cumberland, and to some extent in Cornwall, while large deposits exist near Bilbao in Spain and elsewhere. Deposits of iron ore of considerable promise have been located in South Africa and in the Apuan Alps, between Massa and Lucca, the latter being a hæmatite containing nearly 42 per cent. iron.

Brown hæmatite ($2Fe_2O_33H_2O$), a hydrated oxide of iron, is the source of much of the iron made in France and Belgium, whilst enormous quantities of *spathic ore* (*siderite*) or *clay ironstone* (which is an impure carbonate of iron containing about 33 per cent. of iron, and the poorest of the iron ores that are worked) are used in this country as a source of iron. Iron occurs as carbonate in the forms of *blackband* of the Scotch coalfields, and in an impure form in the neighbourhood of Northampton and the county of Oxfordshire.

Large deposits of micaceous iron ore (known also as *specular iron ore* and *iron glance*) are found in Brazil, and two mines are producing this form of hæmatite in Devonshire. Large deposits of hæmatite ore are known to exist upon certain islands on the eastern coast of Hudson Bay, whilst the Lorraine district is said to contain an iron ore reserve, in the nature of a brown hæmatite, very rich in phosphorus, of about 1,800,000,000 tons, which yielded about three-fourths of their steel output while in German hands.

IRON (*Continued*)—

There are also mineral deposits of hydrated iron oxide or *bog-iron ores,* one of which is known as *limonite,* and of a hydrated basic sulphate of iron and potash known as *jarosite,* in Australia.

The Kent iron ore is stated to give 43 per cent. iron and to be quite suitable for the manufacture of basic pig.

It has been estimated that China possesses 7,000,000,000 tons of iron ore available for treatment by native methods and modern furnaces.

Chromium iron ores come largely from New Caledonia, Rhodesia, the U.S.A. and Canada.

Iron as manufactured and dealt in commercially is not a pure metal, and varies very much in composition and qualities according to the purposes to which it is to be applied. Some of the better-known kinds are named cast-iron, wrought iron, foundry iron, forge iron, steel, etc., and their melting or fusing points and other properties vary with the composition. In sponge form suitable for certain chemical and metallurgical applications it is obtained from its oxide ores by extraction of the oxygen at a temperature below the fusion point of the metal. (See P. Longmuir, *B.C.A.*, 1927, B, 781.)

Electro-deposited Iron—A French process in use at Grenoble and Niagara Falls consists of electrolyzing a concentrated solution of ferrous chloride at 75° C., using anodes of cast iron and a rotating mandrel of steel as the cathode. This gives a deposit of iron upon the steel mandrel of 99·966 per cent. purity and exceptional magnetic quality.

The Eustis process employs an insoluble anode at which oxidation of ferrous chloride takes place, and the metallic iron is deposited on the rotating cathode. The ferric chloride thus formed is led over pyrrhotite iron ore (the cheapest and most abundant in North America), by which it is reduced to the ferrous state, while at the same time iron passes into solution, and sulphur is deposited in the gangue and subsequently recovered as brimstone.

The chemical changes that take place are represented by the equations:

$$3FeCl_2 = Fe + 2FeCl_3,$$

and—

$$2FeCl_3 + FeS = 3FeCl_2 + S,$$

the iron removed from the solution being replaced by that taken from the ore. The metallic iron thus produced is of 99·99 per cent. purity, and finds application in making special steels, boiler tubes, transformers, telegraph wires, parts of aeroplane engines, and as a material for research work, being the purest available form. It is not, however, chemically pure, as it generally contains some small proportions of hydrogen, sulphur, silicon, phosphorus, and traces of carbon.

By heating certain varieties of electrolytic iron in a vacuum for two hours at 1,500° C., gas is evolved equal to two and a half times its own volume, containing 6 per cent. CO_2, 34 per cent. CO, 49 to 51 per cent. H, 2 to 4 per cent. hydrocarbons, and other gases 7 per cent. (R. Hugues, *B.C.A.*, 1926, B, 159).

IRON (*Continued*)—

Various electrolytic methods for producing pure iron are described by D. Belcher (*C.T.J.*, of May 16, 1924), and the production of high quality iron sponge by M. Wiberg (*B.C.A.*, 1927, B, 525).

The corrosion of pure iron is the subject of an article by J. F. G. Hicks (*B.C.A.*, 1929, B, 521), who concludes that the primary cause is the actual dissolution of iron in water which he states to take place before any other chemical change occurs, and that a film of water is essential for corrosion. Ferrous hydroxide is next produced, and subsequently ferric hydroxide or ferrous carbonate, according to varying conditions, which are discussed.

Until some few years ago the annual wastage of iron and steel by corrosion almost amounted to the annual production of pig iron.

Cast or **Pig Iron** is made in blast furnaces (of which there are about 482 in this country) from mixtures of iron ore with coal or coke and limestone, by which means (the contents of the furnace being maintained at bright-red heat by the blast of air) the oxygen contained in the oxides or other iron compounds is burned off by the carbon, the lime combines with the clayey part of the ore and forms the slag, leaving metallic iron. The molten iron settles in a layer at the bottom of the furnace, the *slag*, which is less fusible, remaining on its top. "Pig iron" made in this way, containing from 2 to 5 per cent. of carbon and small quantities of sulphur, phosphorus, and silicon, is used for making stoves, saucepans, iron gates, and many other articles. It is hard and brittle, and, as ordinarily made, is more readily fusible (1,100° C.) than wrought iron, which is made from it by remelting and exposure to further oxidation to burn off more carbon and other impurities. Its uses are limited for temperatures not above 200° C. (say), for low pressures, and for pressures up to 80 lb. per square inch (say) when the temperature is low (Hinchley). The British output of pig iron in 1929 was about 7,579,500 tons, and the world output in 1924 was computed as 64,630,000 tons.

Some years ago, a plant was installed at Sheepbridge (Derbyshire) in which ironstone is fed with low-grade slack into a rotary kiln, whereby at comparatively low temperature iron is produced of a kind stated to be purer and produced more cheaply than by the blast-furnace process. (See Ores and their Treatment.)

Iron is known to exist in two forms according to its temperature: the high-temperature form dissolves carbon, the low one does not.

Ordinary foundry iron contains phosphorus and sulphur in the form of phosphide and sulphide, and as these melt at 1,740° F., cast-iron fire-bars become porous by these compounds running out, leaving metal, which oxidizes rapidly at 1,830° F., thus causing the "burning" of fire-bars, for example. A cast-iron alloy named "Usco" has, it is stated, a higher melting-point, greater tensile strength than the ordinary product, and although more costly initially, can be used beneficially for many applications.

Cast iron is obviously a very variable material, and this has been emphasized by H. J. Young, who has pointed out that the buying and

IRON (*Continued*)—

selling of pig iron by fracture is a useless test (*Ind. Chem.*, 1926, ii., 254). The use of soda-ash as a desulphurizing agent is referred to in *C.T.J.*, 1931, **89**, 132.

Wrought Iron (m.p., 1,600° C.), when heated to redness, is soft, and can be hammered and joined (welded) into any desired shape, a property which is utilized in smithcraft.

The purest form of commercial iron is the fine malleable quality of which wire is made.

Steel (m.p., about 1,350° to 1,375° C.) is produced from wrought iron, which is practically devoid of carbon, by the incorporation of carbon to the extent of from 0·7 to 1·7 per cent., and from cast iron by removing the excess of that impurity. It is, in practice, produced by either blowing or otherwise exposing molten pig iron to a blast of air, which burns out the carbon, together with other impurities, including silicon, manganese, and sulphur.

Steel is regarded by some as a definite crystalline structure in which the size, chemical composition, and disposition of the crystals are regulated by the content of carbon, the work under the hammer and rolls, and the heat treatment.

The manufacture of a ton of steel from hæmatite ore is stated to require 3 to 4 tons coal, 2 tons of ore, and 8 to 9 cwt. limestone.

During the Great War, the electro-thermal steel furnace, which up till then had produced only a small proportion of the metal in this country, came more into use, and by the end of 1918 about 140 furnaces of various types were in use here, with a production of 150,000 tons per annum, the output being principally used in respect of bullet-proof plates, aeroplanes, motor-cars, armour-piercing shells, and steel helmets.

It is stated that on the Tyne electro-thermal steel is now being manufactured at a price which can compete with the acid open-hearth steel, owing to the cheap power of coke-oven gas. The output of steel in this country in 1918 amounted to 9,500,000 tons, while the American production in 1928 was 45,000,000 tons.

So-called mild steel contains from 0·1 up to about 0·4 per cent. of carbon, hardening being effected by the addition of carbon to the outer layers; the harder varieties contain up to about 2 per cent., while the largest amount of carbon that iron can be made to take up is just over 4 per cent., corresponding to the formula Fe_5C.

It is the phosphorus content of the cast or pig iron that determines to some extent the particular process to be adopted for making steel therefrom. Thomas's invention, worked out in association with Gilchrist, enabled steel manufacturers to utilize great deposits of iron ore of a relatively high phosphoric character and therefore not previously suitable, and this process of dephosphorization has been so developed that the greater bulk of steel now produced in the world is made by the so-called "Thomas-Gilchrist" process. In this, dolomite "overburned" at a very high temperature (by which it becomes very hard and dense) is subsequently ground and mixed with boiled tar as a binder; this

IRON (*Continued*)—

mixture being utilized to make the lining of the converters in which the phosphoric iron is converted into steel by burning out the phosphorus carbon and other impurities; the phosphorus going to the slag, which thus becomes available as a valuable fertilizing agent. (See Iron (Slag).) In the absence of phosphorus to any considerable extent, the old Bessemer process suffices, in which the "ganister" (siliceous) lining of the converter is employed, air being blown through the molten mass, thus getting rid of the carbon, but leaving some phosphorus and sulphur in the molten metal, which is made more or less brittle in consequence. The basic lining removes these impurities, as already explained.

In the so-called basic Bessemer process, in which melted pig iron is subjected to a blast of air, the lining of the converter or oxidizer is made of bricks of magnesian limestone cemented together, instead of the siliceous acid material named *ganister*, which was used in the old Bessemer process, with the result that the phosphorus is removed in addition to the other associated impurities, and concentrated in the slag.

In the Siemens-Martin process of steel-making, the cast iron is mixed with specially picked iron ore, using furnaces with open hearths heated by producer gas, and the elimination of phosphorus by burning out is largely due to the high ferrous oxide content of the slag. (See J. Wagner, *B.C.A.*, 1929, B, 721.)

In the final casting of steel into ingots, a small quantity of aluminium is usually introduced, with the object of preventing the formation of blow-holes.

In the manufacture of steel for industrial employment, many other metals are deliberately introduced, manganese, for instance, being used for hardening purposes up to about 1 per cent. in the so-called Bessemer and open-hearth steels, although for some purposes larger quantities are used, the so-called manganese steel containing from 11 to 14 per cent. manganese, possessing certain valuable physical qualities. Nickel is used to produce a toughening effect, and chromium, cobalt, tungsten, molybdenum, tantalum, vanadium, and zirconium are severally employed to give particular properties or qualities to steels destined for special applications. The reactions of the basic open-hearth furnaces form the subject of a paper by T. P. Colclough (*B.C.A.*, 1925, B, 550).

Zirconium steel is extraordinarily hard, and plates of zirconium-nickel steel are stated to be twice as resistant to shot as those of chromium steel.

Steel containing 12 to 14 per cent. chromium and a low percentage of carbon (about 0·3 per cent.)—stainless steel—has been rendered possible only by the electric furnace, which is necessary for the preparation of the ferro-chrome, as also for the steel melting. Steel of this quality is passive to nitric acid of sp. gr. 1·20. (See S. J. Hewitt, *Ind. Chem.*, 1927, iii., 20.)

So-called "Austenitic steels" of acid-resisting quality are described as consisting of a solid solution of carbides in a solid solution matrix of

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chromium and nickel in iron. Some of these contain up to 12 per cent. nickel, 20 per cent. chromium, and varying amounts of other special elements such as copper, molybdenum, tungsten, etc. Certain varieties of these new stainless steels are now used in making culinary utensils and other domestic articles, also in constructional work, as they take a high polish after washing with soap and water and then present a platinum or silver-like appearance. (See W. H. Hatfield (*Chem. and Ind.*, 1929, **48,** 1060, and *Ind. Chem.*, 1931, vii., 477); V. N. Svetchnikov (*B.C.A.*, 1929, B, 1017); and F. M. Becket (*Chem. and Ind.*, 1932, **51,** 49).)

In the "Bassett" process for the production of iron, the oxide is mixed with powdered coal and heated in a rotary furnace at 1,000° C. by means of powdered coal flame, the lower end of the kiln receiving the molten iron and slag. (See Ores and their Treatment.)

In the "Borcoud" process (which, like the "Bassett" process, is of French origin) the iron ore is similarly reduced by carbon monoxide (produced by heating pulverized coal with heated air) in a rotary furnace so lined that the gases are made to follow a long spiral path, and thus come into prolonged contact with the ore, which is made to travel in the opposite direction. In this way the sulphur and phosphorus compound constituents of the ore are not reduced at all, and the temperature of the reduction is so low that these impurities pass directly into the slag together with the silica and manganese compounds, leaving the mass of mainly pure reduced iron in the furnace ready for remelting in an electric furnace in the absence of air.

"V_2A" (Krupp's)—a stainless steel—is a silver-white metal stated to resist the action of nitric acid of any strength and temperature, which can be welded without the aid of other metals.

The "Era" heat-resisting steel is a variety used in the Bertholet calorimeter bomb.

The *hardening* of steel is brought about by rapid cooling after being heated to a high temperature, whilst the *tempering* of steel is effected by reheating the hardened metal to a temperature much lower than that used for hardening it, and cooling slowly. The new nitrogenization process for hardening steels, discovered by Fry, consists of heating them in an atmosphere of ammonia, those containing about 1 per cent. aluminium responding well to this treatment and finding large employment. The theory of steel hardening is the subject of an article by E. Scheil (*B.C.A.*, 1929, B, 97).

M. L. Guillet has also described a process for hardening steel, which consists of heating it in a current of ammonia at 500° to 510° C., thus producing an extremely hard layer which may amount after some time to 0·8 mm. thick, but the steel must contain certain elements which prevent penetration of the nitrogen, which otherwise produces iron nitride and makes the metal fragile.

The production of crude steel in the U.K. in 1929 has been given as 9,654,700 tons, of which about 70 per cent. was made by the open-hearth basic process. The classification of various steels can be made

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to some extent by examining the spark stream emitted when they are ground on an emery wheel, although it cannot replace chemical, mechanical, and metallographic study, and is, of course, only qualitative in character. (See "Sparking of Steel," by E. Pitois (review *Chem. and Ind.*, 1930, **49**, 836); T. E. Hamil on "Quenching Media for Steels" (*B.C.A.*, 1931, B, 1098); and "Progress in the Manufacture of Alloy Steels," by S. J. Hewitt (*Ind. Chem.*, 1931, vii., 19).)

The world output of steel in 1929 was computed at nearly 108,000,000 tons, of which some 90 per cent. was made by the Thomas-Gilchrist process.

Ferro-Alloys are used in the steel industry to remove oxygen and nitrogen from molten steel, or to introduce into the steel a small proportion of some other metal in order to adapt it to special applications.

To remove oxygen, from 0·5 to 1 per cent. of ferro-manganese, ferro-silicon (containing 30 per cent. or more silicon), ferro-aluminium, and ferro-titanium are variously used in very small proportions, the manganese compound being most generally used by reason of its cheapness.

To remove nitrogen, ferro-vanadium (containing from 25 to 40 per cent. vanadium) and ferro-titanium are employed; whilst to introduce the proportion of special metal, ferro-manganese, ferro-vanadium, ferro-chromium, ferro-tungsten, ferro-molybdenum, ferro-titanium, ferro-uranium, ferro-boron, and ferro-zirconium are all used.

A steel containing 12 to 14 per cent. manganese is very tough and hard, and specially adapted for mining and grinding machinery and making burglar-proof vaults; one containing from 2 to 4 per cent. chromium is a very hard tool-making material; that containing 15 to 25 per cent. tungsten is a high-speed steel which will cut iron while red-hot; that containing 6 to 10 per cent. molybdenum is similar to the tungsten variety, and is used for lining large guns to increase their resistance to erosion.

Steel containing from 0·5 to 1 per cent. vanadium is very strong, resists shock well, and is used for making motor-car axles, cranks, piston-rods, etc. The titanium combination containing from 1 to 2 per cent. of that metal is largely used for making steel rails and sheet-steel.

Steel containing about 0·5 per cent. of uranium is said to replace that containing several per cent. of tungsten, and is used for making tools; while the zirconium variety is well adapted for bullet-proof sheets, armour-plate, and armour-piercing projectiles.

Ferro-Carbon Titanium is an alloy containing carbon, which is sometimes used to make steel tougher and ensure very sound castings. (See *C.T.J.*, 1928, **83**, 123.)

Ferro-Cerium (**Pyrophoric Alloys**)—Alloys made with a mixture of rare-earth metals (chiefly cerium) with about 30 per cent. iron; a sparking substance used in making cigar-lighters and for tracing the flight of shells, the friction of the air generating sufficient heat to cause a piece of the alloy attached thereto to burst into flame and thereby

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indicate their path. The cerium is obtained from the residues of the gas-mantle industry.

Ferro-Chrome contains from 50 to 60 per cent. of chromium and 5 to 9 per cent. of carbon.

Ferro-Manganese is an alloy of manganese carbide with iron, and contains from 20 to 85 per cent. of manganese. (See Manganese Steel.)

Ferro-Molybdenum, Ferro-Nickel, and **Ferro-Phosphorus** all have their special applications in steel-making of various qualities, the latter being used when very thin castings have to be made by increasing the fluidity of the metal. (See Molybdenum.)

Molybdenum does not function as a deoxidizer, and its value in steel-making is attributed to the formation of a true alloy.

Ferro-Silicon—Iron alloyed with from 12 to 16 per cent. of silicon is very resistant to the action of acids, and the use of this alloy has largely replaced that of glass and stoneware in chemical industry. It is somewhat brittle, and vessels made of it will not withstand great internal pressure, but up to 50 lbs. per square inch they are considered safe. (See *C.T.J.*, 1926, **78**, 466.) Another extensively used ferro-alloy is one of silicon and iron, containing 30 per cent. or more silicon, but no carbon. It is made by the reduction of silica (preferably a pure grade of quartzite) and iron ore with carbon in the electric furnace, and is used not only in hydrogen-making, but also in conjunction with ferro-manganese as a deoxidizing agent for converting white cast iron into grey iron, and in steel manufacturing. (See Hydrogen, p. 461.)

Ferro-Vanadium—See Vanadium.

Other References: "Notes on Alloy Metals used in Alloy Steels," by J. L. F. Vogel (*J.S.C.I.*, 1924, **43**, 365 T); R. Hadfield (*Chem. and Ind.*, 1925, **44**, 1029); "Chemically Resistant Steels," by Elliot and Wiley (*Chem. and Ind.*, 1926, **45**, 526); "Ferrous Metallurgy" (*Chem. and Ind.*, 1926, **46**, 209); "The Physical Chemistry of Steel-making Processes" (a publication of the Faraday Society, 1926); a review of "The Steel and Alloy Steel Industry in 1927," by S. J. Hewitt (*Ind. Chem.*, 1928, iv., 18); Marson and Cobb and Angus and Cobb on the "Scaling of Steel" (*J.S.C.I.*, 1927, **46**, 61 T); "Influence of Atmosphere on the Scaling of Mild Steel," by Blackburn and Cobb (*J.S.C.I.*, 1930, **49**, 455 T and 463 T); "Heat Treatment of Ferrous Metals," by C. M. Walter (*Chem. and Ind.*, 1928, **47**, 791); "Scope of Corrosion-Resisting Steels," by T. H. Burnham (*Ind. Chem.*, 1928, iv., 320); "Cobalt Chrome Magnet Steels," by H. E. Kershaw (*Ind. Chem.*, 1929, v., 47); "Progress in the Manufacture of Alloy Steels" (*Ind. Chem.*, 1930, vi., 34); "The Relative Safeties of Mild and High Tensile Alloyed Steels under Alternating and Pulsating Stresses," by B. P. Haigh (*Chem. and Ind.*, 1929, **48**, 23), also J. B. Kommers (*Chem. and Ind.*, 1929, **48**, 1223); article on "Modern Applications of Acid-Resisting Iron" (*Chem. and Ind.*, 1929, **48**, 483); "Chemical Action in Relation to Fatigue Failure of Steels," by W. R. Ormandy

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(*Chem. and Ind.*, 1930, **49**, 259); "Protective Coatings for Iron and Steel," by H. N. Bassett (*Ind. Chem.*, 1930, vi., 241 and 293); "Recent Developments in Corrosion and Heat Resisting Steels," by Hadfield, Elliot, and Sarjant (*J.S.C.I.*, 1930, **49**, 41 T); "Fuel Developments in Iron and Steel Practice," by E. C. Evans (*Chem. and Ind.*, 1931, **50**, 568); "Heat-Resisting Steels," by H. N. Bassett (*Ind. Chem.*, 1931, vii., 318); "Industrial Steels and Alloys," by J. W. Donaldson (*Chem. and Ind.*, 1931, **50**, 787 and 838); "Rust and Acid-Resisting Steels," by W. H. Hatfield (*Ind. Chem.*, 1931, vii., 477); "Case-Hardening Steels," see *Mechanical World Year Book*, p. 282 (Emmott and Co., Manchester); *Ferrous Metals*, by Birkett and Dorman (E. Benn, Ltd.); *Practical Steel-making*, by W. Lister (Chapman and Hall, Ltd.); *Acid-Resisting Metals*, by S. J. Tungay (E. Benn, Ltd.); Corrosion, Macrome (Steel) Process, and Rustless Iron.

Slag (**Basic Slag**), or the cinder from blast-furnaces, consists largely of silicates of calcium and aluminium, containing also phosphates in varying proportion. When reduced to powder, it is used as a phosphatic fertilizing material; and in a crushed and pulverized state as a road-making material which, when penetrated with tar, constitutes the material known as "Tarmac." It is also used in making "Vinculum" concrete and a certain quality of glass can be made from it (C. A. Basore, *B.C.A.*, 1932, B, 181).

The phosphide of iron (Fe_2P) representing the state of combination in which the phosphorus exists in molten iron is oxidized by reactions of the type $5Fe_3O_4 + 2P = 15FeO + P_2O_5$ and $5Fe_3O_4 + 8P = 15Fe + 4P_2O_5$. The P_2O_5 may combine with FeO to form $Fe_3(PO_4)_2$, but as this is unstable in the presence of a large excess of iron, a reaction such as $Fe_3(PO)_4)_2 + 11Fe = 8FeO + 2Fe_3P$ results, and it is in consequence of this change that the acid process of steel-making is unable to remove phosphorus. In the basic process, the presence of lime causes the formation of phosphate by the change indicated by the reaction $Fe_3(PO_4)_2 + 4CaO = Ca_4P_2O_9 + 3FeO$. The calcium phosphate thus formed is only feebly attacked by the metallic iron, but manganese and carbon act more vigorously and cause the phosphoric acid to be reduced and the metal to be rephosphorized, a tendency which is restrained, however, by maintaining a certain concentration of ferrous oxide.

The high reputation basic slag has acquired for the improvement of poor pastures is said to be indirect and to result from a stimulation of the white clover, although it is not definitely known whether the action of the phosphate is on the clover-plant or on the nodule organisms. It contains from 16 to 20 per cent. phosphoric acid in combination with lime, etc. The new so-called basic, "open-hearth" process gives two qualities of slag, both of which are poorer in phosphates and contain on average from 9 to 13 per cent. phosphoric acid in combination, but it is stated that the high soluble open-hearth basic slags have the same agricultural value per unit of phosphoric acid as the old Bessemer slags. One is made by a process involving the use of calcium fluoride, and is consequently less soluble than the other, whereas that made without

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fluorspar is as effective as the old Bessemer slag when compared on the basis of equal amounts of phosphorus content. The demand for basic slag is so great that it is computed British agriculturists could utilize as much as three to four hundred thousand tons per annum if available.

In certain experiments made at Cockle Park, untreated pasture yielded about 20 lbs. of lean meat per acre per annum, whereas after treatment with slag the yield rose to 105 lbs. of meat per acre. Moreover, after eleven years' treatment with basic slag the percentage of nitrogen in the soil increased from 0·185 to 0·286 per cent.—a gain of about 850 lbs. per acre.

As preferred for agricultural dressing, the slag is ground sufficiently fine to allow 80 per cent. of the total weight to pass through a sieve having 10,000 apertures to the square inch. The value of commercial deliveries in the past has not been based upon the phosphate total content, but upon that portion of it which is soluble in a 2 per cent. solution of citric acid under certain prescribed conditions formulated by the Board of Agriculture. It has, however, been pointed out that the slag varies in quality so enormously that the proportion of phosphate dissolved by 2 per cent. citric acid solution also greatly varies—viz., from about 6 to 29 per cent.—showing that this test and the total phosphate content is not sufficient to afford reliable information of the fertilizing values of different qualities of basic slag. E. Vanstone has proposed the use of a 2 per cent. solution of oxalic acid for evaluation of the relative solubilities of phosphates in basic slag and mineral phosphates and states that they are in good agreement with their availability as shown by pot experiments (*J. Agric. Sci.*, 1925, **15,** 491-496, or *J.S.C.I.*, 1925, **44,** 155 T). The essential fertilizing constituents of slags is a matter of some doubt, and by some it is considered likely that the silico-phosphates are the most valuable.

Slag is also variously used in cement-making, as a packing material, in making fire-proof compositions, and in powdered form in France as an insecticide for the eradication of a particular parasite affecting the sugar-beet.

The annual output of basic slag in the United Kingdom was about 221,498 tons in 1928, and the world's production in that year about 5,200,000 metric tons.

A standard suggested by the British Chemical Standards Movement for basic slag "A" is as follows:

Phosphoric anhydride (P_2O_5)	12·93	per cent.
Equal to phosphates ($Ca_3(PO_4)_2$)	28·24	,,
Iron	8·97	,,
Silica	16·15	,,

So-called "slag wool" (slag bestos) is made from slag by blowing air or steam through or against it when in melted form, being thereby converted into fine threads like cotton-wool, and in this form it is used as an insulating material, a filtering medium, covering for steam-pipes,

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boilers, etc., and as a packing material. Its heat insulating power largely depends upon the fineness of its fibres. A similar product is also manufactured from rocks of appropriate character, such as natural siliceous limestone or calcareous shale, which, when in a molten state and blown by high-pressure steam, give the longest, finest, strongest, and most resilient fibres. (See C. D. Abell on "Blast Furnace Slags" (*Ind. Chem.*, 1932, viii., 110).)

Iron Carbide—See Carbides.

Iron Carbonyls—See Metallic Carbonyls.

Iron Oxides—The three known oxides of iron are ferrous oxide (FeO), ferric oxide (Fe_2O_3), and the so-called magnetic oxide (Fe_3O_4, or FeO,Fe_2O_3), the ferrous and ferric salts being derived from the first two named oxides by combination with acids.

The yellow "ferrite" oxides of iron are valuable as paint pigments.

Ferrous Oxide (FeO) is a black powder which oxidizes in the air. In combination with water as ferrous hydroxide ($Fe(HO)_2$), it is precipitated in almost white form when potassium hydroxide solution is added to a solution of a ferrous salt, but it rapidly absorbs oxygen from the air, and gradually passes into ferric hydroxide ($Fe_2(HO)_6$), which is used as a pigment. This hydroxide can also be prepared in gel form. (See Colloid Chemistry, p. 226.)

Rust consists of a mixture of the two hydrated oxides and ferrous carbonate, and continued exposure to air effects the oxidation of the ferrous compounds into ferric oxide (Fe_2O_3).

Ferric Oxide can be prepared in two interconvertible forms, magnetic and non-magnetic, and many hydrates are known to exist. (See Thiessen and Köppen, *B.C.A.*, 1930, A, 559.) The ordinary oxide (colcothar) is red and non-magnetic, while the other variety is brownish-yellow and nearly as magnetic as magnetite (Fe_3O_4). The red variety is reduced by hydrogen at 500° C. to Fe_3O_4 (Abraham and Planiol, *J.C.S. Abs.*, June, 1925, II., 587).

Ferrous sulphate when calcined at from 600° to 1,000° C. yields ferric oxide (red oxide) (Fe_2O_3), the colour of the product varying considerably according to the temperature used, the lower temperatures yielding the lighter shades. There is a process (Neill's) for making it from spent pickling liquors, the ferrous sulphate prepared therefrom being roasted in a current of air to make the ferric oxide. (See J. A. Reavell, *J.S.C.I.*, 1928, **47**, 347 T.) Ferric oxide, by reason of its hardness, is greatly used as an abrasive and polishing material, while *bloodstone* (a hard kind of red hæmatite), when well polished, is considered the best material for producing a high lustre on coat buttons and on the gilding of porcelain. In the pulverulent form, the ferric oxide, obtained by the combustion of ferrous oxalate and other methods, is particularly esteemed for its grinding and polishing characters. *Jewellers' rouge* for polishing gold and silver is produced by lightly calcining ferrous

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sulphate, while the article named "*crocus*," used for polishing brass and steel, is produced by further calcination.

Ferric oxide is also used for colouring glass and porcelain, and the red ferric oxide paint is an important article of commerce, considerable quantities being made in the provinces of Jaen and Malaga from hæmatite ore, which is finely ground and washed with water, the finest product being collected and dried. Apart from its use as a paint for ships' bottoms and ironwork, ferric oxide is utilized as a colouring material for paper, rubber, tiles, etc. Some commercial oxides contain from only 25 per cent. ferric oxide upwards, but many users specify for at least 80 per cent., and the best qualities contain from 92 to 95 per cent. The high grades of Spanish oxides contain from 80 to 95 per cent. of Fe_2O_3. (See Venetian Red.)

Ferric Hydroxide ($Fe(OH_3)$) can be prepared by interaction of solutions of ferric salts and sodium hydroxide and separation by filtration. Prepared as a gel it can be used in common with silica gel for the recovery of solvents; 100 parts containing 6·36 per cent. water is stated by Ferry to absorb 50·2 parts acetone, 6·36 parts ammonia, 6·7 parts gasolene, 10·1 parts benzene, 10·8 parts ethyl alcohol, and 28·2 parts methylene chloride.

Iron Oxide Pigments are prepared from the several oxides or mixtures of them—black, yellow, brown, grey, green, red, and purple in colour—by methods of control which have been described by P. Fireman (*C.T.J.*, 1925, **76**, 757). Useful information concerning these pigments and their microscopic characters is afforded in a recent paper by H. Wagner, abstracted in the *Jl. Society of Dyers and Colourists*, December, 1930, and reported in the *C.T.J.*, 1931, **88**, 15. (See Ochres.) Specifications in respect of the red oxides of iron, as used in the paint and other trades, can be obtained from the B.E.S.A., 28, Victoria Street, London, S.W. 1. The electrolytic production of turkey-red shades of iron oxide pigments is the subject of an article by W. H. Bruckner. (See *C.T.J.*, 1930, **86**, 525.)

Ferric Chloride ($FeCl_3$) can be made by exposing iron turnings to the action of dry chlorine at over 1000° C., but a lower temperature suffices if some carbon be mixed with the iron and a little air with the chlorine. It is obtained in a dark violet crystalline form which distils at from 450° to 500° C. (J. E. Adadurov). In combination with water it is obtained in the form of yellow deliquescent crystals ($FeCl_3,6H_2O$) by dissolving iron in aqua regia, or ferric oxide in hydrochloric acid, and crystallization from the solution. It is soluble in water, and is used in medicine, in the chlorination of silver and copper ores; also as a mordant in dyeing.

Ferric Nitrate ($Fe(NO_3)_3.9H_2O$) is a greyish-white, crystalline salt, soluble in water, used in the textile industries. It is also marketed in the form of aqueous solution of 80° Tw.

Ferric Sulphate ($Fe_2(SO_4)_3$) can be prepared by the action of sulphuric or nitric acid, or both, on ferrous sulphate in solution :

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$$6FeSO_4 + 3H_2SO_4 + 2HNO_3 = 2NO + 4H_2O + 3Fe_2(SO_4)_3,$$

and is obtained by evaporation of the solution as an anhydrous salt.

A combination with water ($Fe_2(SO_4)_3,9H_2O$) is also known.

Ferric sulphate is used to some extent in medicine, in pigment-making, as a sewage precipitant, and for the coagulation of blood in abattoirs, etc.

A double sulphate of iron and potassium, known as iron alum ($K_2SO_4,Fe_2(SO_4)_3 24H_2O$), can be prepared in the form of violet octahedra by dissolving the proper quantity of potassium sulphate in a strong solution of ferric sulphate at 0° C. and crystallization.

Ferric-Ammonium Sulphate ($Fe(NH_4)(SO_4)_2 12H_2O$) is a violet efflorescent salt, soluble in water, used in textile dyeing, etc.

Ferric-Ammonium Citrate—A bronze, hygroscopic, crystalline salt used in photography and medicine.

Ferric Acetate ($Fe_2(C_2H_3O_2)_6$)—A reddish crystalline salt, soluble in water, used in textile dyeing.

Ferric Dichromate ($Fe_2(Cr_2O_7)_3$)—A soluble compound used as a pigment.

Ferrous Chloride ($FeCl_2$)—Used as a mordant and in metallurgy, can be obtained in pale blue-green crystals in combination with water ($FeCl_2,4H_2O$) by dissolving iron in hydrochloric acid and crystallization from the solution. The anhydrous chloride is produced when iron wire is heated in gaseous hydrochloric acid, the chloride volatilizing and subliming in white deliquescent crystals; it is used in the manufacture of jointless magnesite flooring.

Ferrous Sulphate or **Green Copperas** ($FeSO_4,7H_2O$) results from dissolving metallic iron in dilute sulphuric acid, and is obtained upon evaporation of the resulting solution in pale green crystals of an efflorescent character, which are soluble in water (70 parts in 100 at 15° C.). Upon heating to 100° C. these crystals lose 6 molecules of water, and the residual compound is therefore $FeSO_4,H_2O$.

It is also recovered from the pickling liquor from sheet or tube mills, which contains about 40 per cent. $FeSO_4,7H_2O$, and used as an insecticide in horticulture, also in making inks, pigments, Prussian blue, etc. (See Ferric Oxide.)

Ferrous Acetate ($Fe(C_2H_3O_2)_2$) is extensively used, under the name of "iron liquor," as a mordant in dyeing.

Ferrous Sulphide (FeS) is a nearly black compound, insoluble in water, and in a fused form is used for generating hydrogen sulphide by the action of acids thereon. In air it begins to oxidize at 400° C., and is converted into a mixture of magnetite and ferric oxide at 1,000° C. In common with pyrites, it is used for generating sulphur dioxide (by burning) in the sulphite process of preparing wood pulp, etc.

Iron combines with sulphur to form several other distinct sulphides (Fe_2S_3 and FeS_2, the last named being found in nature in large quantities as iron pyrites); there is also a so-called *magnetic pyrites*

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(Fe_3S_4) found in hexagonal crystals of a magnetic character. Iron disulphide is stated to be the principal product when pure ferric oxide in a dry state is exposed to the action of hydrogen sulphide between 120° C. and 400° C. (See L. A. Sayce, *J.C.S.*, 1929, p. 2002.)

Ferrous Oxalate ($FeC_2O_42H_2O$), in the form of pale yellow crystals insoluble in water but soluble in acids, is used as a photographic developer.

Ferrous Iodide (FeI_24H_2O) is a crystalline body soluble in water, used in the manufacture of alkali-metal iodides.

Ferrous Fluoride (FeF_28H_2O) is a heavy white substance used in ceramics and in the manufacture of alkaline fluorides. (See also Ferrates and Ferrites, and Prussian Blue.)

Ferrocyanides and **Ferricyanides**—See Cyanogen Compounds.

IRON CARBONYL ($Fe(CO)_5$) is said to be formed when water gas or coal gas is stored under pressure in steel cylinders, and it can be prepared from iron oxalate by heating at 370° to 380° C. in a slow stream of hydrogen until the evolution of carbon dioxide ceases; the product is then cooled to 55° C. and exposed to a stream of carbon monoxide and the gas cooled to $-80°$, when the liquid iron carbonyl is condensed. (See Griffith and Halliday (*J.S.C.I.*, 1928, **47,** 311 T); R. L. Mond and A. E. Wallis on "Metallic Carbonyls" (*C.T.J.*, 1926, **78,** 189); King and Sutcliffe (*J.S.C.I.*, 1928, **47,** 356 T); Hieber and Vetter (*B.C.A.*, 1931, A, 1255).)

IRON LIQUOR—See Ferrous Acetate, p. 503.

"IRON MORDANT"—Trade name for ferrous sulphate.

IRON PYRITES—Iron disulphide. (See Iron and Pyrites.)

"IRONAC"—A proprietary, hard, cast-iron silicon alloy of acid-resisting character, advocated for use in making chemical plant. (See Iron (Ferro-Silicon).)

IRONE—A methyl ketone ($C_{13}H_{20}O$), isomeric with ionone, constituting the odoriferous constituent of the iris root, and possibly that of the violet; it can be prepared from citral, and is the basic source of several compounds for the manufacture of violet essence. (See Ionone.)

IRONSTONE—See Iron.

IRRIGATION is a process often employed for the disposal of sewage, and consists in allowing it or the effluent from it (resulting from preliminary treatment or deposition of the heavier solid parts) to slowly drain off or filter through the land, over which it should be fairly evenly distributed. A light loamy soil is the most suitable, and great purification is effected, whilst the land is, at the same time, fertilized for the growth of cereals and vegetables. The nature of the purification that occurs is explained under the heading of Nitrification. As supplies of suitable land are not generally available, specially prepared bacterial filter-beds of ashes or charcoal and other materials have now come into more general use. (See Nitrification and Sewage.)

IRVINGIA—See Dika Butter.

ISATIN (o-Amino-phenyl-glyoxylic acid Lactam)—

$$(C_8H_5NO_2 \text{ or } C_6H_4\left\langle\begin{matrix}CO\\NH\end{matrix}\right\rangle CO)$$

—A synthetic, reddish-yellow, crystalline substance of m.p. 200° C., fairly soluble in hot water, ether, and alcohol, which can be prepared by the oxidation of indoxyl (C_8H_7ON) with nitric acid or hypochlorous acid, the equation, using hypochlorous acid, being expressed as follows:

$$C_8H_7ON + 2(HOCl) = C_8H_5NO_2 + 2HCl + H_2O.$$

It is convertible into aniline by the action of potash 200° C. and is used in dyeing.

ISINGLASS (Ichthyocoll)—A pure commercial form of gelatin made from the internal membranes (inner layer of the sound) of the bladders of the sturgeon, and used as an adhesive, also for clarifying wines, vinegar, beers, and other preparations. Inferior sorts are from cod, ling, and hake sounds, sole skins, and fish-bones; indeed, there are a number of commercial qualities of varying degrees of purity, but all more or less good enough for various applications. The food value of isinglass in terms of calories is stated to be about 1,510 per lb. It is transformed into gelatin by a degree of heat below blood temperature. (See Adhesives and Glue.)

ISO—A prefix signifying equal or identical, as isomeric, isobares, isotopes, etc.

ISOBARES (Isobars)—A term given to atoms stated to have identical atomic weights, but differing in chemical properties—a deduction made from mass spectra observations. (See Isotopes and Transmutation.)

ISOCYCLIC—See Homocyclic.

ISO-ELECTRIC—Point of electric neutrality.

ISO-EUGENOL—See Cloves.

ISOLOGOUS—Having similar proportions or relations, as, for example, groups of homologous terms, in which radicals, by combining with a series of similar elements, produce other series of similar compounds; thus, ethane (C_2H_6), ethene (C_2H_4), and ethine (C_2H_2) constitute an isologous series of isologues; the difference between these compounds being other than CH_2.

ISOMERISM—Substances composed of the same number of the same atoms, but differing in molecular construction (architecture) and properties, are described as *isomeric*. Thus, ordinary alcohol and methyl ether have the same percentage composition and empirical formula (C_2H_6O), but are perfectly distinct substances, the constitutional formulæ being regarded as respectively C_2H_5HO and $(CH_3)_2O$. There are many such cases, particularly among organic compounds, as, *e.g.*, the bodies known as terpenes—that is, the hydrocarbons forming the chief constituents of the various essential oils—all of which have the common composition $C_{10}H_{16}$, and yet differ largely in their chemical and physical properties. They are therefore described as

ISOMERISM (*Continued*)—

physical isomers. Varying amounts of heat are consumed in the formation of any two isomeric bodies, and so, when decomposed, there is a corresponding difference in the evolution of heat, showing that varying amounts of energy are required to build up the different molecular structures of isomeric bodies.

Isomers of the same molecular weight are described as metameric, while those of dissimilar molecular weights are described as polymers.

Stereo-isomerism—Isomerism arising from the rearrangement in space of the atoms or radicals in a molecule round a central polyvalent atom.

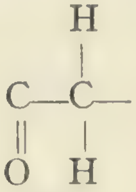
Thus two compounds may contain the same atoms and radicals, and have identical chemical and physical properties, and yet differ in their action upon polarized light.

In the case of active carbon compounds, these atoms and molecules are four in number, and if they are imagined to occupy the corners of a tetrahedron containing the quadrivalent carbon at its centre, then it will be found that such an arrangement necessitates two "stereo" or space isomers, which correspond to the positive and negative varieties of the compound. Valeric acid ($C_5H_{10}O_2$), for example, apart from its other modifications, possesses two stereo-isomers, and the groupings in this case are the four different radicals H, CH_3, C_2H_5, and CO_2H.

A diagrammatic representation which has found some favour in respect of compounds, such as potassium cobaltinitrite, $K_3(Co6NO_2)$, is that of an octohedron in which the six co-ordinated groups occupy identically similar positions.

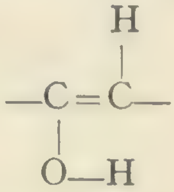
Tautomerism is a type of isomerism attributable to intramolecular rearrangements, so that a substance may react in accordance with varying structural formulas, and it has been suggested that the term should apply to all reversible isomeric changes.

An example of such reversible changes is afforded by certain ketonic esters, where the group (*a*) easily changes into the group (*b*), and *vice versa*. (See Thorpe and Ingold, *Chem. and Ind.*, 1923, **42**, 612.)



$$\begin{array}{ll} & \mathrm{H} \\ & | \\ \mathrm{C} & \!\!—\mathrm{C}— \\ \| & | \\ \mathrm{O} & \mathrm{H} \end{array}$$

(*a*)



$$\begin{array}{ll} & \mathrm{H} \\ & | \\ —\mathrm{C} & \!\!=\mathrm{C}— \\ | & \\ \mathrm{O}—\mathrm{H} & \end{array}$$

(*b*)

The resultant isomers exhibit varying chemical functions, and others similar chemical properties, etc., but all are due to the particular character of the structure of the substances concerned, as to which there is much speculation, the most recent views being based upon the electronic theory of atomic structure. For detailed information concerning the various types of isomerism, such as cis-trans, chain, dynamic, geometrical, ionic, etc., see Conch's *Dictionary of Chemical Terms* (D. Van Nostrand Company, N.Y.). (See also Co-ordination, Formulæ, Metameric, and Polymerism.)

ISOMORPHISM—See Crystals, p. 254.

ISOPRENE (C_5H_8 or $CH_2:CMe.CH:CH_2$)—A volatile liquid hemiterpene, yielded by the destructive distillation of pure rubber, also obtainable from turpentine by the action of heat, and which by contact with certain reagents, such as hydrochloric acid, becomes converted partly into rubber. It is colourless, boils at 37° C., and is of interest in connection with the attempted synthesis of rubber on a commercial scale. (See Rubber.)

ISOPROPYL ALCOHOL (C_3H_8O) or ($CH_3.CH(OH).CH_3$)—A so-called secondary alcohol which yields a ketone (acetone) upon oxidation. It is a colourless mobile fluid of sp. gr. 0·789 and b.p. 82·8° C., made from acetone by reduction with sodium amalgam or by catalytic hydrogenation. It is soluble in alcohol and ether and is miscible with water in all proportions; used commercially as a solvent and preservative (being as good as ethyl-alcohol for the extraction of drugs like belladonna, benzoin, capsicum, cinchona, henbane, and nux-vomica), and as a solvent in making perfumes, cosmetics, etc. As to its manufacture, see Curme and Reid (*B.C.A.*, 1929, B, 275). "Avantine" is a make of isopropyl alcohol of which 95 per cent. is of b.p. 81° to 82° C.

ISOTONIC—See Osmosis.

ISOTOPES—A term introduced to explain the alleged existence of very nearly allied forms of some chemical elements (sub-atomics), the general chemical properties being identical, but exhibiting slight variation in their atomic weights or mass; each element consisting of as many isotopes as its atoms have different masses. Other of the elements are regarded as simple, their mass numbers corresponding exclusively to their atomic weights (see table, pp. 303 and 304) and list of them (*Chem. and Ind.*, 1931, **50**, 777).

Dillon, Clarke, and Hinchy make claim to have succeeded in separating the isotopes of lead, having values 207·1 and 207·4 respectively. (Compare Lead, p. 524.)

According to the atom-nucleus theory, isotopes possess atoms having the same net positive charge on their nuclei, but different numbers of protons and electrons in these nuclei, and therefore different (atomic) weights or mass. Whatever speculative interpretations physicists may give to them, isotopes can be viewed by chemists as chemical entities or the products of chemical changes, possibly degraded in character, not necessarily identical with the mass of the originating substances, or conceivably resulting from minute impurities associated with the subjects of operation. (See article on "Material Chemistry and Immaterial Matter," by C. T. Kingzett (*C.T.J.*, 1922, **70**, September 8); *Radio-elements and Isotopes*, etc., by K. Fajans (McGraw Hill Publishing Co.); Atoms, Elements, Light (Mass Spectroscope), Nascent, Protyle, Radio-activity, and Transmutations; also F. W. Aston's boow (Ed. Arnold, London).)

ISOVALERIC ALDEHYDE (**Isovaleral**) [$(CH_3)_2CHCH_2CHO$]—A colourless liquid of apple odour, b.p. 92° C., sp. gr. 0·804, soluble in

ISOVALERIC ALDEHYDE (*Continued*)—
alcohol and ether; made by oxidation of amyl acetate, and used in perfumery and for flavouring, etc.

IVORY—Essentially *dentine*, the main constituent of all teeth, and chiefly obtained from the upper incisor teeth of the African elephant; containing about 57 to 60 per cent. calcium salts (chiefly phosphate), 40 to 43 per cent. organic matrix, and 0·24 to 0·34 per cent. fat. The teeth of the walrus, hippopotamus, sperm-whale, etc., furnish material which owing to its density can be used in place of ivory for many purposes.

IVORY BLACK—A fine, velvety, carbonaceous black, largely composed of mineral matter (65 to 75 per cent.), including calcium phosphate, prepared by carbonizing ivory-turnings and waste, and used by copper-plate printers in making their ink; also as a decolourizing and filtering agent.

IVORY (VEGETABLE)—See Vegetable Ivory.

"IZAL"—A proprietary fluid disinfectant, being a ready-prepared emulsion of phenoloids, including xylenols.

JABORANDI—The dried leaflets of *Pilocarpus jaborandi* (*P. pennatifolius*), indigenous in Brazil. Other varieties are imported from Paraguay, Rio, and other countries. Used as a sudorific. (See Pilocarpine.)

JADE (Tremolite)—Several distinct minerals are known by this name, the true jade, *nephrite* (a hard, tough variety of amphibole), being an anhydrous double silicate of calcium and magnesium ($3MgO,SiO_2 + CaO,SiO_2$) of sp. gr. about 3. Jade is greenish-white to deep green in colour, nearly as hard as quartz, and a favourite material for making ornaments and amulets. It is extensively found in China, New Zealand, Eastern Turkestan, Siberia, and the Philippine Islands. *Jadeite,* which resembles it, is a silicate of aluminium and sodium. (See Asbestos.)

JALAP—The dried root of the plant *Ipomœa purga,* of the order Convolvulaceæ (Off., *Exogonium purga*, U.S.), which grows in Tampico (Mexico), and is cultivated in Jamaica and India. It furnishes about 10 per cent. glucosidal resins, containing about 90 per cent. convolvulin ($C_{31}H_{50}O_{16}$) and about 10 per cent. jalapin ($C_{34}H_{65}O_{16}$). The resin constitutes a powerful purgative.

Other varieties come from Brazil and elsewhere. (See Convolvulin and Gums and Resins (Scammony).)

JAMS—Certain standards for jams adopted by the jam section of the Food Manufacturers' Association (Incor.), and arrived at in conjunction with the Society of Public Analysts, provide that all jams so named or otherwise as "conserves" and "preserves," of both first and second qualities shall contain not less than 68½ per cent. of total soluble solids (by refractometer reading when cold uncorrected for insoluble solids); and definite percentages of fruit content both in respect of single-fruit jams and mixed jams. Particulars of other provisions can be obtained from above-named Association (22, Buckingham Gate, London, S.W. 1). (See *Analyst*, 1930, **55,** 695, and T. Macara (*Ibid.*, 1931, **56,** 35).)

JAPAN—A lacquer for metallic and wooden articles, made by heating a mixture of linseed oil, litharge, and Prussian blue, thinned with turpentine or naphtha.

JAPAN TALLOW—See Waxes.

JAPAN WAX—See Waxes.

JAPANNING—Varnishing or lacquering in which the Japanese excel, consisting in heating the varnished articles, after application of each coat, in an oven to a high temperature. Ivory black and animé varnishes are used amongst other materials, colours being introduced as required. (See W. J. Miskella (*B.C.A.*, 1932, B, 196).)

JAROSITE—A mineral hydrated basic sulphate of iron and potassium occurring in Victoria (Australia), from which red oxide of iron and potassium sulphate are obtainable.

JASMINE OIL, distilled from the flowers of *Jasminum grandiflorum*, and other species of which there are about one hundred (N.O. Oleaceæ), is nearly colourless or reddish-brown; the general yield is under 1 per cent. It contains benzyl and linalyl acetates and linalol; has a sp. gr. of about 1·0, opt. rot. +2·5 to 3·5, and is used in perfumery and soap-making. (See Tsuckihashi and Tasaki, *J.S.C.I.*, 1919, **38,** 117 A.)

To obtain the delicate odour and piquancy of jasmine, extensive use is made of amyl cinnamic aldehyde, a synthetic perfume of recent achievement. (See *C.T.J.*, 1929, **85,** 8.)

JASPER—A kind of quartz. (See Chalcedony and Silica.)

JATROPHA—A genus of euphorbiaceous plants, the root of one of which (*Jatropha manihot*) yields tapioca. (See Tapioca.)

JAVELLE—See Eau de Javelle.

JELLIES—Jelly strength. See A. F. Tracey (*J.S.C.I.*, 1928, **47,** 94 T); Lockwood and Hayes (*Ibid.*, 1931, **50,** 145 T); J. P. Laurie (*Ibid.*, 1930, **49,** 403 T); "Theory of Jelly Formation," by S. Prakash (*J.S.C.I.*, 1931, **50,** 387 T). (See also Agar-Agar, Gels (p. 225), and Gelatin.)

"JELUTONG"—The resinous material from the latex of *Apocynaceæ Dyera*, used in making chewing gum. (See Gums (Pontianic).)

JET—Supposed to be wood in an advanced state of bitumenization (lignite), abundant in the upper lias shale near Whitby in Yorkshire, also found in Colorado, the island of Skye, and various parts of the European continent. It is of varying hardness, sp. gr. about 1·3; used as fuel and for making ornamental articles.

"JEYES' FLUID"—A coal-tar disinfectant, miscible with water.

JOULE—See Force and Heat.

JOULE (JOULE-THOMPSON) EFFECT—When gases at high pressure are forced through a porous plug or small orifice, they become cooler, excepting hydrogen, which becomes warmer, although below −80° C. it is also cooled. The "effect" is due to internal work overcoming molecular attraction. (See R. W. Lunn (*J.S.C.I.*, 1925, **44,** 247 T).)

JUNIPER—Coniferous plants, of which about twenty species are known (including *Juniperus communis* and *J. phœnicia*), the berries of which yield upon distillation with water from under 1 to 2·5 per cent. of a volatile essential oil, containing from 25 to 50 per cent. pinene, 15 to 25 per cent. cadinene, juniper camphor, etc. It has a sp. gr. 0·865 to 0·882 at 15° C.; i.v., about 285; sap. v., 14 to 15; ref. ind., 1·472 to 1·488 at 20° C.; and opt. rot., $-3°$ to $-12°$ at 20° C. It is of turpentine-like odour, somewhat soluble in alcohol and ether, and used for flavouring gin and hollands.

According, however, to J. L. Simonsen (*Indian Forest Rec.*, 1924, **11,** 1-9), the oil from *Juniperus communis* contains about 50 per cent. *d*-satinene, but *a*-pinene is absent.

The plants are indigenous in Great Britain, are found widely throughout Europe and the north of Asia, and the extracted oils vary a good deal in chemical characters.

A description of Norwegian juniper oil is given by A. Jermstad (*B.C.A.*, 1929, B, 536).

JUTE—The bast fibre (inner bark) of the *Corchorus capsularis* and *C. olitorius* (N.O. Tiliaceæ), the culture of which is chiefly carried on in Bengal. It is extensively manufactured in Dundee, and is woven in India into gunny bags and cloth, which are largely used in the Southern States of America for cotton packings. It is also used in the manufacture of carpets, cellulose, and various tissues, twine, and paper. A published analysis (*J.C.S. Abs.*, cxxviii., 1, 518) of an average clean sample showed a cellulose content of 69·63 per cent. and a lignin content of 18·83 per cent. The action of chlorine on jute fibre is the subject of a paper by H. W. Strong (*J.S.C.I.*, 1928, **47,** 196 T). According to N. K. Sen, the extraction of jute seeds with light petroleum gives 14·73 per cent. of an oil which, when purified with alkali, has d^{28} 0·923, $n^{29 \cdot 7}$ 1·4615, solidifying-point $-20°$ C., i.v. 102·6, sap. v. 184·6, acid v. 1·5, acetyl v. 27·3, Reichert-Meissl v. 0·16, and is described as suitable for food and for burning (*B.C.A.*, 1929, A, 477). Further details of the composition of the seeds are given by the same authority (*B.C.A.*, 1930, A, 826). (See Cellulose.)

KACHI GRASS OIL—The grass *Cymbopogon cæsius* gives by steam distillation 0·14 to 0·37 per cent. of oil resembling ginger-grass oil; acid value 0·9 to 2·5, sap. v. 13·2 to 31·2. It darkens upon exposure, and is said to contain dipentene, limonene, geraniol, and perillic alcohol.

KAFIR—See Sorghum.

KAINITE (**Kainit**)—One of the Stassfurt mineral deposits, consisting of potassium and magnesium salts, variously represented as (K_2SO_4,$MgSO_4$,$MgCl_2$,$6H_2O$) and (KCl,$MgSO_4$,$3H_2O$), used as a fertilizer in respect of crops such as oats, and stated to kill certain undesirable weeds, including charlock. (See Potassium.)

KALAW SEEDS, from *Asteriastigma macrocarpa* and other species, yield an oil described by Peacock and Chit Thoung (*J.S.C.I.*, 1931, **50,** 7 T).

"KALKAMMON"—A mixture of chalk (30 per cent.) with ammonium chloride used as a fertilizer.

"KALSOMINE"—A preparation of china clay for colours, such as reds, greens, and blues, which are not alkali-proof.

KAOLINS—Forms of china clay which upon dehydration at high temperatures are resolved into Al_2SiO_5 or Al_2SiO_7. According to Ross and Kerr, kaolin consists of at least three distinct minerals, most of which conform to the formula $Al_2O_3,2SiO_2,2H_2O$ (*B.C.A.*, 1930, A, 569). (See Clays, Porcelain, and Sillimanite.)

KAPAYANG OILS (from seeds of *Hodgsonia heteroclita* and *Pangium edule*), yielded to extent of 57·4 and 21·9 per cent. respectively, having a density of 0·922, sap. v. 203·9 and 199·5, and i.v. 63·6 and 107·3.

KAPOK—The Malay name given to the cotton-like down produced in the seed-pods of the tree of that name (*Eriodendron anfractuosum*), and extensively used in making life-saving jackets, etc. The dried seeds yield about 22 per cent. of oil of sp. gr. 0·9217 to 0·9235 at 15° C., i.v. of about 95, and sap. v. about 190; used as food and for soap-making. The cake contains about 4 per cent. nitrogen and is of value as a feeding stuff. (See Trevithick and Dickhart (*Analyst*, 1931, **56**, 670); Griffin and Alsberg (*B.C.A.*, 1931, B, 982); and Cruz and West (*B.C.A.*, 1931, B, 1060).)

"KARBOS"—A char made from charred sawdust purified by acid treatment, and admixed with animal carbon; used for decolourizing.

"KAROLITH"—A casein-formaldehyde plastic.

KARRI BARK (*Eucalyptus diversicolor*)—A source of tannin material.

KATERGY (Law of)—See Force, p. 366.

KATHAROMETER (Shakespear)—An instrument for measuring the thermal conductivity of a mixture of gases of known nature to determine its composition.

KAURI GUM—See Gums and Resins, p. 425.

KAURI OIL—Obtained by the distillation of the gum-containing peat from the kauri gum-lands of North Island (Auckland), the yield being about 40 gallons per ton. It consists largely of the products of cracking the gum which is distributed in the peat, and resembles in complexity of character crude resin oil.

KAUWA BARK (from *Piper methysticum*)—An Indian tanning material containing about 35 per cent. tannin and 40 per cent. calcium oxalate—a valuable by-product. The root of the plant contains a resin and various other chemical compounds. (See *Chem. Soc. Annual Report,* 1929, **26**, 149.)

KAWA RESIN—See Gums and Resins.

KEENE'S CEMENT—See Cement.

KEILHANITE—See Thulium.

"KEK" MILL—See Grinding.

KELP—The ashes of burnt sea-weeds, containing sodium carbonate, sulphate and sulphide, together with the chlorides of potassium and

KELP (*Continued*)—

sodium, and insoluble substances comprising calcium carbonate, silica and alumina. Kelp was at one time utilized for the extraction of both alkali and iodine, the latter being recovered from the mother-liquor remaining after the crystallization of the salts from the extracted ashes. Two published analyses give the percentic parts as follows:

Potassium sulphate	8·0–19·0
Soda as carbonate and sulphide ..	8·5– 5·5
Potassium and sodium chlorides ..	36·5–37·5
	53·0–62·0 soluble parts.
	47·0–38·0 insoluble parts.

In one process, the dried kelp is fed into a retort kept at a temperature of about 980° C. to obtain oil, creosote, ammonia, etc., by distillation, and the charred residual mass is cooled, ground and lixiviated, first of all with a concentrated brine, fresh water being used for the final extraction. According to King (Fuel Research Board, Tech. Paper No. 9), a ton of dry sea-weed gives about 8·18 cwt. of solid residue, 22·4 gallons tar, 48·4 gallons liquor capable of yielding 33 lbs. of ammonium sulphate, and 3,857 cubic feet of combustible gas (14·7 therms) by low-temperature distillation method, the iodides and other salts being contained in the residue. The charcoal residue contains 35·74 per cent. carbon and 64·26 per cent. ash, from which latter the potash salts and iodine (amounting to about 0·5 per cent. NaI on the dry weed) can be obtained. A ton of kelp (obtainable from 20 tons of wet weed) is said to yield 5 cwts. of potassium chloride, 2 cwts. of potassium sulphate, 3½ cwts. of kelp salt (sodium chloride), and 9½ cwts. of waste—that is, insoluble matter resulting from lixiviation.

The pressed coke can be saturated successively with hot hydrochloric acid and water, and after pulverization is used as a decolourizing agent.

After removal of the sulphates from the brine liquor, it is concentrated in a vacuum pan to a certain point and then transferred to a vacuum crystallizer, in which the potassium chloride deposits. Upon further concentration the sodium chloride separates, whilst from the mother-liquor iodine is obtained.

In another process, the kelp is fed into one end of a rotary kiln, in which it encounters a flame of burning oil from the other end, thus producing a charcoal-like mass which is subsequently quenched, ground, and leached (lixiviated), or it may be burned to a grey loose ash with a potassium content equal to about 35 per cent. K_2O.

About 8 lbs. iodine can be extracted from a ton of Scotch kelp. (See Barilla, Iodine, Sea-weeds, Varec, Vriac.)

"KENNEDY" OIL METER—See Chemical Plant.

KERASIN—A nitrogenous non-phosphorized principle of brain-matter.

KERATIN—A gelatinous substance obtained from hoofs, nails, and hair of animals, which yields leucin, tyrosin, aspartic acid, etc., upon hydrolysis.

KERMES—The oldest dye on record, being the dried bodies of a female insect (*Coccus ilicis* L.), collected in Africa and some eastern parts of Europe, and used for dyeing scarlet "fez" skull-caps, but the colour, which is chemically related to carminic acid, has less bloom than that given by cochineal. It is stated to be useless as a dye without the use of a mordant. With aluminium mordant it gives a crimson colour.

KERMESITE (Kermis)—An antimony ore ($2Sb_2S_3,Sb_2O_3$), of crystal system, No. 4, and sp. gr. 4·5.

"KEROL"—A phenoloid disinfectant which emulsifies with water.

KEROSENE—A mineral illuminant and fuel oil fraction which can be distilled from the natural petroleum deposits in America, Papua, New Guinea, Australia, etc. Sp. gr. about 0·800 to 0·810 and b.p. ranging from 150° to 300° C. (See Petroleum.)

KESSO OIL (Japanese Valerian Oil)—A green oil of some medicinal value; sp. gr. 0·965 to 1·000, opt. rot. 20° to 35°, and ref. ind. 1·4775 to 1·4875. (See Valerian.)

KESTNER EVAPORATOR—See Evaporation and Heat (p. 438).

KETO—Prefix indicating content of the carbonyl group $:C:O$.

"KETOL"—A solvent for pyroxylin lacquers and enamels made by the fermentation of sawdust in presence of lime followed by dry distillation of the calcium butyrate thus formed, the product containing "butyrone" and other ketones. (See Butyric Acid and Solvents.)

KETONES—A class of organic bodies produced by the oxidation of the secondary alcohols, and characterized by containing the carbonyl group ($:C:O$). They are nearly related to the aldehydes, from which they may be considered as derived by the displacement of H in the COH group by the alcohol radicals. Thus ethyl aldehyde (C_2H_4O or CH_3COH) becomes $CH_3CO(CH_3)$—the formula of dimethyl ketone (or, as it is commonly called, acetone (C_3H_6O or $(CH_3)_2:C:O$))—which is the lowest member of the simple series (containing two alkyl groups of the same kind). Again, iso-propyl alcohol by oxidation yields acetone by the withdrawal of two hydrogen atoms:

$$C_3H_8O \text{ or } CH_3CH(OH)CH_3 + O = CH_3(CO)CH_3 \text{ (Acetone)} + H_2O.$$

Methyl-ethyl ketone (methyl acetone) ($CH_3COC_2H_5$), a so-called mixed ketone (the alkyl groups being different), is a colourless inflammable liquid of acetone-like odour with a sp. gr. of 0·808, b.p. 79·6° C.; used in making smokeless powder and as a solvent.

Ketones containing two $C:O$ groups are termed di-ketones, and aryl groups may in any case replace alkyl groups.

KETOSES—Monosaccharoses of ketonic character. (See Carbohydrates.)

"KHARSIVAN"—The name of a British make of "salvarsan."

KIER BOILING—A term used in respect of boiling textile tissues with caustic soda solution with or without pressure; or with a mixture of lime

KIER BOILING (*Continued*)—
and water. Sodium carbonate is sometimes used as a milder alkaline reagent, and sometimes the term "scouring" is used to describe the operation. Unless the cotton waxes and resinous contents are well removed the subsequent bleaching is rendered more difficult.

A method for the disposal of "Kier" liquors produced by this treatment of cotton, etc., prior to bleaching is described in the *C.T.J.*, 1930, **86,** 387, and the process of Kier bleaching with hydrogen peroxide (*Ibid.*, 1930, **87,** 286).

KIESELGÜHR (Infusorial Earth, Diatomite)—There are many grades, one of the best—a soft, white, porous, light, earthy deposit of hydrated silica—being the siliceous skeletons of minute aquatic plants known as diatoms, found at Digby Neck in Canada, Germany, the U.S.A., and many other parts of the world. It is generally associated with earthy impurities, and contains from 65 to 87 per cent. SiO_2, 2·3 to 11·7 per cent. Al_2O_3, up to 3 per cent. Fe_2O_3, small proportions of the oxides of calcium, magnesium, potassium, and sodium, and from 5 to 14 per cent. water.

It is of great absorbent capacity, one variety being capable of taking up about four times its own weight of water and having a sp. gr. of about 0·33. Calcination is often resorted to for the removal of organic matter and improvement of colour.

It is largely and variously used as an absorbent for carrying liquid petroleum; in the manufacture of dynamite; as a filtering material; in ceramics; as an abrasive, cleanser, and polishing agent; as a filler; and in compounding mixtures for boiler coverings, etc. The value of diatomite as a filtering medium is the subject of an article by V. L. Eardley-Wilmot (see *C.T.J.*, 1929, **84,** 71); also Infusorial Earth, Silicon, and Tripoli.)

KIESERITE—Mineral magnesium sulphate ($MgSO_4,H_2O$) found in the Stassfurt salt deposits, and used for making Epsom salts.

KILNS—Descriptions of the Dunnachie continuous gas-fired kiln and the Belgian ring kiln are given by S. R. Hind (*Trans. Ceram. Soc.*, 1929, **28,** 148-164, 204-219), and abstract (*B.C.A.*, 1929, B, 518); "The Hot-patching of Kilns, Retorts, and Refractory Surfaces" is the subject of a paper by H. Pardoe (*Chem. and Ind.*, 1929, **48,** 962). (See also Calcination and Lime.)

KILO (Kilogram)—See Weights and Measures.

KILOMETRE—See Weights and Measures.

KILOWATT—See Force, p. 369.

KIMMERIDGE CLAY or SHALE—The lowest series of the upper oolite found as a deposit under the sands beneath the Portland stone of Dorsetshire and elsewhere, abounding in animal and vegetable matters. It is used to some extent as fuel, and yields on distillation petroleum-like products containing a high percentage of sulphur (5 to 8 per cent.), some of it being in the form of thiophen. F. Challenger has given a

KIMMERIDGE CLAY or SHALE (*Continued*)—
summary of the principal types of sulphur compounds detected in such oils (*Chem. and Ind.*, 1929, **48**, 139). (See also Petroleum and Shale.)

KINETIC ENERGY—See Force, p. 369.

KINETIC THEORY—See Force (p. 369) and Gases (p. 392).

KING'S YELLOW—Trade name for arsenic trisulphide.

KINO—A generic name for the concreted (inspissated), astringent juice from the trunks of at least four varieties of trees; used as a drug, being of an astringent character.

African kino, or *gummi gambia*, comes from the *Pterocarpus erinaceus;* the Asiatic kind from *Pterocarpus marsupium;* the New Holland variety from the *Eucalyptus resinifera;* and the American kino from *Coccoloba urifera.* Marri kino (red gum from *Eucalyptus calophylla*) is stated to contain from 68 to 70 per cent. of matters absorbable by hide powder.

The African kino is particularly rich in tannin, and is used in both the tanning and textile industries. (See Tannins.)

KIPP'S APPARATUS—See Gas Generators.

KIRSCHWASSER—An alcoholic liqueur obtained by fermenting and distilling pulped cherries.

KISH—Crystalline graphite deposited in iron furnaces from molten iron upon cooling.

KISIDWE NUT FAT—From a species of *Allanblackia* (probably *A. floribunda*) growing on the Gold Coast. A hard, white fat of faint odour yielded to the extent of 73·2 per cent. by extraction with light petroleum, calculated on the dry kernels, or 44·2 per cent. upon the entire nuts; fit for soap-making, but the residual meal is bitter and astringent. The shell forms 38 per cent. of the nut.

"KISOL"—A proprietary covering for boilers and steam-pipes, said to be superior to plastic magnesia and asbestos composition.

KJELDAHL'S PROCESS for determining the nitrogen content of organic substances consists of heating with concentrated sulphuric acid after addition of a little anhydrous potassium sulphate (in order to raise the boiling-point), whereby the nitrogen content is converted into ammonium sulphate, and on rendering the mixture alkaline with sodium hydroxide, the ammonia is distilled off and the amount determined. It is used, among other purposes, in respect of blood, but is not universally applicable to organic compounds. A modification of this process for use in respect of sewage effluents, etc., is described by J. W. A. Johnson (*Analyst*, 1926, **51**, 405); see also H. M. Chiles (*J. Amer. Chem. Soc.*, January, 1928).

"KLINGERIT"—A proprietary jointing material for steam-pipes, stated to resist high pressure and many chemicals.

KNOCK RATINGS—See Motor Spirit.

KNOPPERN (**Knopper Galls**)—A tannin material in the form of excrescences produced by insects (*Cynips calicis*) upon the immature acorns

KNOPPERN (*Continued*)—
or flower-cups of certain species of oak—principally *Quercus cerris* of the Slavonic plains—and known as *sisarca* and *gubacs*.

KOJIC ACID—See Saki.

KOKA-SEKI—A variety of pumice found in the Niijima Islands, used as a building material and for the construction of reinforced concrete barges, etc. (See Pumice Stone.)

KOLA (COLA or GURU) NUTS (Soudan Coffee)—From the seed-kernels of *Cola vera* (N.O. Sterculiaceæ) (West Africa), containing caffeine in some combination to extent of from 2 to 2½ per cent.; used in medicine. (See P. Casparis, *B.C.A.*, 1930, A, 1223.)

"KOLLAG"—See Lubricants.

"KONTAKT"—A liquid saponifier for use in the Twitchell process.

KOPPERS' PROCESS—See *Ind. Chem.*, 1931, vii., 517; Coke Ovens, Gas (Coal), and Nitrogen (p. 614).

KŌRYŌ OIL (Millet Seed Oil), from *Andropogen sorghum*, var. *vulgaris*, Hack (Mancha). (See Ueno and Kuzei (*B.C.A.*, 1931, B, 124, and *Analyst*, 1931, **56**, 117).)

KOUMISS—Fermented mare's milk used in Tartary as a vinous food; something similar is said to be made in the Orkneys. An intoxicating spirit called "rack" is distilled from koumiss.

"KRAFT"—See Paper.

KRAMERIA—See Rhatany Root.

KRYPTON (Kr)—Atomic weight, 82·9. A very rare element isolated from liquefied air, and contained in the air to the estimated extent of 1 part in 1,000,000. It is a colourless and inert gas, credited with six isotopic forms, but no chemical compounds of it are known. According to Allen and Moore, it has a m.p. of $-156{\cdot}6°$ C. (*B.C.A.*, 1930, A, 1508).

KUKKERSITE (Kukersite)—See Shale.

KUPFERNICKEL (NiAs) (crystal system, No. 3, and sp. gr. 7·3 to 7·6)—See Nickel and Arsenic.

KURRAJONG SEED OIL—The seeds of kurrajong (*Brachychiton populenum*) yield about 17 per cent. of a clear, red, syrupy oil of semi-drying character, with a sp. gr. 0·9206, sap. v. 189·5, and i.v. 97.

KUSUM OIL—See Macassar Oil.

KYANIZING—A process to protect wood against decay by treatment with an aqueous solution of mercuric chloride. The wood is steeped in a ⅔ per cent. solution, kept up to strength by adding more of the salt from time to time, different species of wood exhibiting variations in rate of absorption. Fir and pine wood must be treated for ten and seven days respectively to attain equal absorption. (See Wood.)

"KYNAZITE"—A proprietary, inert material for strengthening and waterproofing concrete and mortar.

LABDANUM—A perfumery base of resinous nature which collects on the fleeces of sheep from certain species of rock rose, and from which it is combed.

LABORATORY—A simple chemical laboratory (workshop) consists essentially of a working bench, preferably made of teak and polished with wax, about 3 feet from the ground, fitted with drawers and a raised shelf running along the back, upon which can be placed bottles of the requisite chemical reagents. The bench should be provided with either a lead-lined wooden or a glazed earthenware sink; a water-supply pipe with one or more taps; also a gas-supply pipe with two or three **T**-piece connections and taps, to which the various lamps and burners ordinarily used can be attached. In cupboards or on a shelf below may be placed the larger pieces of apparatus, and chemical supplies that are only occasionally wanted, whilst the drawers in the bench are useful for the storage of small appliances and requisites.

Tiles form the best wall covering, but acid-resisting glazed paints or enamels are more economical, and serve quite well for most purposes. (See Note on the furnishing and equipment of Chemical Laboratories (*J. Chem. Soc.*, December, 1921) and *Ind. Chem.*, 1926, ii., 502.)

LABOUR IN INDUSTRY—See Occupational Figures.

LABRADORITE (**Labrodite**)—A mineral of the lime-soda felspar order, of crystal system, No. 6, and sp. gr. about 2·7, which takes a beautiful polish and exhibits changing colours (iridescence).

LAC—See Shellac.

LACMOID (**Resorcinol Blue,** $C_6H_3(OH)_2.NOOH.C_6H_8$)—An indicator prepared from resorcinol by treatment with sodium nitrite; soluble in alcohol, ether, but only slightly so in water. (See Volumetric Analyses.)

LACQUERS—Natural varnishes, as, for example, the milky latexes of certain trees; others consisting of shellac (with or without added hard gums) dissolved in alcohol or other solvent, and coloured as desired with saffron, annato, dragon's blood, etc.; also the various nitro-cellulose solutions, some millions of gallons being now annually made from pyroxylin. These last-named lacquers, which are extensively used for the carriage work of motor-cars, are almost exclusively applied by spray, a suitable brush form not having yet been devised. A great saving of time is gained by their use, but it has not yet been definitely ascertained what combination constitutes the best undercoating medium.

The "blooming" of freshly lacquered surfaces is generally due to the use of constituent materials which allow the dew-point of the atmosphere to be too quickly reached by reason of rapid volatility, thus causing the deposition of moisture and consequent precipitation of the body in solution. Frosting effects in certain lacquers can be produced by introducing some finely powdered synthetic resins which are initially soluble in the combined solvents, but which subsequently crystallize out upon the evaporation of the solvents.

A survey of present knowledge concerning cellulose acetate lacquers is given by Hofmann and Reid in their paper referred to below. These possess some advantages over nitro-cellulose lacquers, being non-inflammable and exhibiting greater stability, while non-inflammable chlorinated solvents may be used in respect of them. Their adhesive

LACQUERS (*Continued*)—
character, however, is not so good as that of the nitro-cellulose lacquers, which primarily consist of two parts—viz., the volatile solvents used in their preparation and the non-volatile portions; the former being the nitro-cellulose solvent alcohol and hydrocarbon, and the latter the nitro-cellulose, the plasticizer, and any pigments used in compounding them. The proportions and other details vary according as to whether the product is to be used for films or as lacquers.

References: The use of certain glycerol derivatives in the manufacture of some lacquers by Fairbourne, Gibson, and Stephens (*Chem. and Ind.*, 1930, **49**, 1021); "Modern Lacquer Industry" (*C.T.J.*, 1925, **76**, 541, and 1926, **79**, 275); "Cellulose Enamels" (*Ibid.*, 1926, **78**, 102); A. E. Lain (*B.C.A.*, 1926, B, 373); Hofmann and Reid (*C.T.J.*, 1929, **85**, 365) on "Cellulose Acetate Lacquers"; B. M. Pam on "The Effect of Thinners on the Viscosity of Nitro-cellulose Solutions" (*J.S.C.I.*, 1929, **48**, 223 T); H. S. Garlick (*Chem. and Ind.*, 1927, **46**, 336); W. J. Jenkin on "Nitro-cellulose Lacquers and Enamels" (*Chem. and Ind.*, 1928, **47**, 1243); "Cellulose Lacquers" (*C.T.J.*, 1928, **82**, 147 and 163; 1928, **83**, 232); T. H. Durrans (*Ibid.*, 1931, **88**, 53); R. J. Daniels (*Ind. Chem.*, 1928, iv., 104); B. Campbell on "Nitro-cellulose Finishes" (*C.T.J.*, 1928, **83**, 431, and 1929, **84**, 49); C. E. Watson on "Nitro-cellulose Lacquers" (*Chem. and Ind.*, 1929, **48**, 1206); A. Ll. Matthison on "The Lacquering of Food Containers and Closures" (*Chem. and Ind.*, 1930, **49**, 474); a description of a cellulose lacquer factory (*Ind. Chem.*, 1930, vi., 393); A. Samson on "Lacquer and the Canning Industry" (*Chem. and Ind.*, 1932, **51**, 95); *Solvents (for Lacquers)*, by T. H. Durrans (Chapman and Hall, Ltd.); *The Cellulose Lacquers*, by S. Smith (Sir Isaac Pitman and Sons, Ltd.); and a Memorandum on the Manufacture, Use, and Storage of Cellulose Lacquers (Form 826, H.M. Stationery Office); Dopes, "Duco," Nitro-cellulose, Pyroxylin, and Varnishes.

LACTIC ACID (**Acid Alpha-hydroxypropionic Acid**) ($C_3H_6O_3$ or $CH_3.CH.(OH).CO_2H$)—There are two isomeric varieties of lactic acid. The common lactic acid is represented as above, and that of ethylene-lactic acid as having the constitution $CH_2(OH).CH_2.CO_2H$. The ordinary lactic acid of commerce results from, and is largely manufactured by, the bacterial fermentation of milk, whey, cane or grape sugars, maize, and starch, using the lactic bacilli which cause the acidity of soured milk. As thus made from starch, milk, or sugar, the acid is neutralized as the fermentation proceeds (at a temperature of about 34° C.) by addition of calcium carbonate, and the solution of calcium lactate is subsequently concentrated and decomposed with sulphuric acid. When sterilized saccharine matter, such as glucose, is used in this process in the presence of chalk and nitrogenous matter, very high yields of calcium lactate are obtained. It is also produced by the action of caustic potash solution upon grape or cane sugar with heat. (See Windisch (with others), *B.C.A.*, 1927, A, 1053.) Its manufacture and utilization has been described in detail by "Omega" (*C.T.J.*, 1929, **84**,

LACTIC ACID (*Continued*)—

559-560, and 581-582), and an article on the industry in the U.S.A., by J. F. Garrett, is given (*Ind. Eng. Chem.*, November, 1930).

The pure liquid acid has a sp. gr. of about 1·2485, is soluble in water and alcohol, and used in the leather and textile industries, also in medicine, mordanting, etc. It is best known in a state of solution, but can be obtained in crystalline form, which melts at 18° C. Lactic acid is said to be rapidly replacing the more expensive citric and tartaric acids in the compounding of soft drinks and infant foods in the U.S.A., while a small addition is stated to improve the quality of beer of low-alcohol content by combining with the amines and amino-acids. For commercial and edible purposes, lactic acid is prepared of 50 per cent. and 60 per cent. strength.

There are two active modifications of this acid, one dextro and the other lævo-rotatory, while a mixture of the two is of inactive or racemic character.

Upon heating, lactic acid is partially converted into lactide ($C_6H_8O_4$)—its anhydride m.p. 125° C.—and when heated with dilute sulphuric acid, it splits up into acetaldehyde and formic acid. All the lactates are soluble in water.

LACTOMETERS (Galactometer, Lacto-Densimeter)—Instruments for determining the purity of milk by its sp. gr., in order to ascertain if water has been added or cream removed therefrom. Modifications are known as mobile-scale densimeters. (See M. Settinj, *B.C.A.*, 1926, B, 105.)

LACTONES—Anhydrides of the hydroxy acid series (of which glycollic and lactic acids are important members) or cyclic esters formed by the elimination of water from a hydroxyl group and a carboxyl group present in the same molecule.

LACTOSE or MILK SUGAR ($C_{12}H_{22}O_{12},H_2O$)—The white sugar contained in milk (about 4½ per cent.), of which four modifications are known. It is prepared on a considerable scale in Switzerland and elsewhere from the whey obtained in cheese-making, by concentration and crystallization. It is somewhat sweet, soluble in water, decomposes at 203·5° C., and is used in the preparation of infants' and other special foods, pharmacy, brewing, and medicine. It resembles maltose, with which it is, perhaps, stereo-isomeric and is not fermentable until hydrolysed. Its manufacture from skim milk is described by F. P. Nabenhauer (*Ind. Eng. Chem.*, January, 1930). (See Milk.)

LADANUM OIL—A yellow essential oil of ambergris odour and sp. gr. 1·01, obtained by distillation of the gum resin of *Cistus creticus* and other kinds of cistus growing in Crete and parts of Asia Minor; used in perfumery.

LÆVO-ROTATORY—See Polarization.

LÆVULOSE—See Fructose.

L'AFZELIA BRIEYI—Found in the Belgian Congo, yields an oil without preliminary decortication to the extent of 29·84 per cent. on the dried fruit; ref. ind. 1·475, sap. v. 184, and i.v. 144.

LAKES—The pigments obtained, as a rule, by precipitation from dyestuffs and other colouring matters. Some are formed by combination with such materials as tannic acid, casein, resin soap, and sodium phosphate, and others with some metallic hydroxide. Aluminium hydroxide ($Al(HO)_3$) enters into combination with many soluble organic colouring matters, thus precipitating them as so-called "lakes" in calico-printing and dyeing. The aluminium hydroxide acts as the mordant, but the same dye can give rise to different coloured lakes according to the nature of the mordant that is used. As many salts of calcium, magnesium, zinc, and tin, etc., are used, a wide range of pigments can be obtained. The lakes produced from certain dyestuffs are useless as pigments owing to their hard and horny nature, but if produced on a suitable base or "extender," such as barytes, china clay, blanc fixe, etc., this difficulty is overcome. Lakes are also used in the preparation of lithographic and printing inks. (See H. Clayton on "The Manufacture and Uses of Colour Lakes" (*J. Society of Dyers and Colourists*, xlvi., No. 7, p. 154), or report thereof (*C.T.J.*, 1930, **87,** 175); *The Manufacture of Lakes and Precipitated Pigments,* by A. W. C. Harrison (Leonard Hill, Ltd., 1930); Dyes, Inks (Printing), and Pigments.)

LAMP-BLACK—Finely divided carbonaceous deposit resulting from the imperfect combustion of natural gas and lamp and other oils and fatty substances, naphthalene, etc. The blackening of the glass chimney of a paraffin lamp is due to the deposition of lamp-black. It is manufactured of great purity for use in making blacking, black paint, brushes for dynamos, carbons for arc-lamps and electrodes, printer's ink, etc. (See F. Grove-Palmer (*Chem. and Ind.*, 1929, **48,** 60); and Carbon.)

"LAMPEN" BALL MILL—An appliance for testing wood-pulps by beating.

LAMPS (Electric)—See A. E. Williams on chemistry of their manufacture (*C.T.J.*, 1931, **89,** 579-580 and 601-602.

LANARKITE—Crystal system, No. 5, and sp. gr. 6·3 to 7·0. (See Lead.)

"LANOLINE"—See Adeps Lanæ.

LANTERN SLIDES—See Photography.

LANTHANITE—A mineral containing lanthanum carbonate associated with cerium carbonate (crystal system, No. 4, and sp. gr. 2·6).

LANTHANUM (La) **and its Compounds**—Atomic weight, 138·9, with alleged isotope of number 139; sp. gr., about 6·15; m.p., 810° C. A rare element of the cerium group, found in *cerite, allanite,* and *lanthanite,* also in *orthite* in Greenland, and in association with other elements in *gadolinite* (*ytterbite*). It is a metal of lead-grey colour, and can be prepared by the electrolysis of fused lanthanum chloride. It readily oxidizes in the air and decomposes water slowly with the evolution of hydrogen. The salts of lanthanum in solution are colourless, and upon addition of a solution of potash or soda a bulky, gelatinous hydroxide ($La(OH)_3$) is precipitated. (See L. Y. Gamboa on "Preparation of Lanthanum from Cerite" (*B.C.A.*, 1931, A, 51).)

Lanthanum forms two oxides (the better known of which is La_2O_3),

LANTHANUM (*Continued*)—
insoluble in water; a chloride known in the anhydrous state ($LaCl_3$), which is soluble in alcohol, and can be obtained in a crystalline form in combination with water; also a number of other compounds, including the nitrate ($La(NO_3)_3 6H_2O$), the sulphate ($La(SO_4)_3 9H_2O$), (both of which are crystalline salts soluble in water), and the carbonate $La_2(CO_3)_3.3H_2O$, which is used in making incandescent gas mantles.

LAPIS LAZULI—A translucent, fine blue, native compound silicate of aluminium, calcium, and sodium of crystal system, No. 1, and sp. gr. about 2·4, found in crystalline limestone on the Indus, and in granite in Persia, China, and Siberia. It is highly valued as a beautiful mineral for vase-making, and at one time "ultramarine" was prepared from it.

LARD and LARD OIL—Hog-fat has a sp. gr. 0·935, m.p. from 41·3° C., sap. v. 195·4, ref. ind. 1·4539 at 60° C. The oil cold-pressed from lard has a sp. gr. of from 0·915 to 0·923, sap. v. about 195, and i.v. 56 to 74. It contains a large percentage of olein with varying percentages of the glycerides of solid fatty acids, including a little arachidonic acid. (See Brown and Deck (*J. Amer. Chem. Soc.*, 1930, **52,** 1135) and letter by T. McLachlin (*Chem. and Ind.*, 1932, **51,** 167).) It is soluble in alcohol, ether, benzol, etc., and is variously used as food, lubricant, in soap and candle-making, for oiling wood, and in compounding metal-cutting preparations, etc. Its tendency to rancidity is lessened by slight hydrogenation. (See p. 338.)

LARKSPUR—See Delphinine.

LATENT HEAT—See Heat, p. 440.

LATEX—The sap of plants, supposed in certain cases to precede the formation of cells. Gutta-percha is the coagulated product of latex from the *Isonarda percha* tree. (See Gutta-Percha and Rubber.)

LAUDANUM—Tincture of opium, prepared by dissolving granulated opium in dilute alcohol—a powerful anodyne and soporific.

LAUGHING GAS or NITROUS OXIDE—See Nitrogen Compounds.

LAUNDRY MATERIALS—See book by D. N. Jackman (Longmans).

LAUREL OIL (Bay Oil)—A bright, yellow, volatile oil of aromatic odour, soluble in alcohol, ether, and chloroform; distilled from the berries and leaves of *Laurus nobilis*, and used in medicine; sp. gr. 0·915 to 0·936 at 15° C., and opt. rot. −15° to −25°. It contains 25 to 50 per cent. cineol, together with some pinene, linalool, and eugenol, etc. It is also accompanied with a saponifiable oil containing lauric acid, obtained when the leaves or berries are boiled with water, and the laurel soap made from it is of medicinal value. The leaves yield about 2·4 per cent., and the berries about 1 per cent. oil. The berries of the Californian *Oreodaphne Californica* are stated to yield 7·6 per cent. oil. (See R. Sansone (*B.C.A.*, 1926, B, 645).) The fat extracted with light petroleum from the fruit freed from shells and purified from the accompanying essential oils by distillation in steam is said to be of acid v. 5·31; sap. v. 210·85; i.v. (Hübl) 67·94; and to contain 84·69

LAUREL OIL (*Continued*)—
per cent. insoluble fatty acids yielding 58·5 per cent. liquid fatty acids. (See G. Wallrabe, *B.C.A.*, 1929, B, 859 and 946.) The glyceride structure and composition of the fatty acids of laurel oil is given in a paper by Collin and Hilditch (*J.S.C.I.*, 1930, **49**, 143 T). See also Heiduschka and Müller (*B.C.A.*, 1930, B, 291) and Ratovski and another on "The Oil from *Laurus reobilis* L." (B.C.A., 1930, B, 1130); also Umbellularia Oil, Lauric Acid.

LAURENT'S ACID—See Acid, Laurent's.

LAURIC ACID ($C_{12}H_{24}O_2$)—A member of the normal fatty acid series and a notable constituent of oil of laurels or fat of the bay-tree (*Laurus nobilis*). It can also be obtained from pichurim beans, cocoa-nut and other oils; it melts at 43° C., and is soluble in hot alcohol.

LAURITE—See Ruthenium.

"LAUTAL"—An aluminium-silicon (2 per cent.) copper (4 per cent.) alloy, more resistant to corrosion than aluminium, with a tensile strength of 40 kg. per sq. mm. and a Brinell hardness of 88; it resembles "Duralumin" in many respects.

LAVA—See Pumice-Stone.

LAVENDER (SPIKE) OIL—The yellowish essential oil from the flowers of *Lavandula spica* L., containing linalool, borneol, cineol, and some terpene; sp. gr. 0·900 to 0·915 at 15° C.; opt. rot., $-2°$ to $+3°$; and ref. ind., 1·462 to 1·467 at 20°; soluble in alcohol, ether, etc., and used in perfumery and liniment making. It varies in character attributable to varying methods of preparation and nature of the soil on which the plant is grown. (Compare Volmar and Thurkauf on "Concrete Essence of Lavender," *B.C.A.*, 1929, B, 1050.)

LAVENDER FLOWER OIL is distilled from the flowers of *Lavandula officinalis*, and is more fragrant than the spike oil. The yield is about 1 lb. from 56 lbs. of flowers. It is nearly colourless, of sp. gr. 0·885 to 0·897 at 15° C., opt. rot. $-3°$ to $-9°$, and ref. ind. 1·460 to 1·468 at 25°; soluble in alcohol, ether, etc., and used in perfumery. It contains about 60 per cent. linalool, 21 to 45 per cent. linalyl acetate, geraniol, and cineol.

LAWSONITE—A mineral double silicate of calcium and aluminium ($CaO,Al_2O_3,2SiO_2,2H_2O$); crystal system, No. 4, and sp. gr. 3·1.

LAZULITE—A mineral crystalline form of hydrated phosphate of aluminium, magnesium and iron found in Styria, Brazil, N. Carolina, etc.; sp. gr. 3·0. A specimen from Graves Mountains (Georgia) has been described as calcium lazulite, corresponding to the formula $(Fe,Mg,Ca)O,Al_2O_3,P_2O_5,H_2O$.

LEACHING—The washing out or extraction of soluble constituents from metalliferous or other insoluble parts of substances. The process is used, for example, in the extraction of sodium nitrate from caliche, the treatment of cupreous pyrites for the extraction of associated metals,

LEACHING (*Continued*)—
and the extraction of tanning and dye materials, by such appliances as the Thornycroft patent apparatus. (See Lixiation.)

LEAD (Plumbum, Pb) **and its Compounds**—Atomic weight, 207·2; sp. gr., 11·4; m.p. 327·4° C. Lead occurs naturally, for the most part, in the form of *galena* or lead sulphide (PbS), in the U.S.A., Australia, Mexico, Bolivia, Upper Silesia, and Spain, the British production, once considerable, being now almost a negligible factor, and the U.S.A. the largest producer. It also occurs as carbonate ($PbCO_3$) in *cerussite* (white-lead ore) in Cornwall, Cumberland, Scotland, Mexico, and some of the U.S.A.; as sulphate ($PbSO_4$) it is present in *anglesite*; in *lanarkite* as a basic sulphate ($PbSO_4$,PbO) or ($PbSO_4$,$PbCO_3$); in *massicot* (found in some of the U.S.A.) as monoxide (PbO); in *matlockite* as basic chloride ($PbCl_2PbO$), etc.; large quantities of lead vanadate (*vanadinite*) are found in the Transvaal and at Tsumeb, whilst a rich mine exists in Burma. The production of lead ores on certain horizons of the lower carboniferous formations in England and the Lower Palæozoic formations in Great Britain decreased steadily from 80,850 tons in 1877 to 14,784 tons in 1918. In 1913 the world's production of lead was 1,700,000 tons.

The metal is produced by several processes, one of which consists in roasting lead sulphide in a reverberatory furnace at a certain temperature, whereby some of it is oxidized into lead sulphate ($PbSO_4$) and some into lead oxide (PbO), a part of the sulphur being burnt off as sulphur dioxide (SO_2). Upon increasing the temperature, a further change takes place in the mixture which still contains some lead sulphide, and metallic lead results from the two interactions—$PbSO_4 + PbS = 2Pb + 2SO_2$ and $2PbO + PbS = 3Pb + SO_2$; that is to say, the rest of the combined sulphur is burnt off, and the metallic lead thus produced is subsequently refined. By another method the ore is smelted with coke and iron or a suitable iron ore, whereby iron sulphide is formed as a regulus, which floats over the metallic lead which is thus set free. The associated metallic impurities (antimony, tin, copper, etc.) are removed by oxidation in a reverberatory furnace, collecting in a dross on the surface of the lead. Silver, when present, is later removed by a process to be described.

In other metallurgical processes, a saturated solution of salt (which is a good solvent for lead chloride and lead sulphate) is used, and from the solution so obtained (when not contaminated with other elements) the oxide is precipitated by the action of lime, or (when contaminated with other elements) by electrolysis, the metallic lead being obtained from the oxide by reduction.

Details of the "Betts" electrolytic lead-refining process are given by J. J. Fingland (*B.C.A.*, 1930, B, 512). Acid lead fluosilicate is used as an electrolyte in this process, the hydrofluosilicic acid required being preferably made by retorting a mixture of high-grade fluorspar and sulphuric acid and passing the hydrofluoric gas into water containing finely crushed quartz or silica in suspension, by which means a solution containing about 33 per cent. hydrofluosilicic acid (H_2SiF_6) is obtained.

LEAD (*Continued*)—

If inferior fluorspar be employed in the retorting process, silicon fluoride (SiF_4) gas accompanies the H.F. gas, but is also resolved into H_2SiF_6 in contact with water, accompanied by gelatinous SiO_2; but this modification of the process is not so economical.

The process used for the desilverization of lead is based upon the use of zinc, which, when mixed in a molten state with argentiferous metal, solidifies first, and abstracts the greater part of the silver. It is, however, the undesilverized lead, otherwise known as "chemical lead," which is used in the forms of pipes and sheets and for lining tanks so extensively in chemical industries. The B.E.S.A. specification of "chemical lead" gives its content as 99·99, but if copper be present the lead content may be reduced to the extent of the copper content. The presence of the small content of copper is considered by some as an advantage, while the small percentages of other metals (silver and bismuth) are negligible. The importance of purity as a factor concerning lead used in making chemical plant has been the subject of much discussion. (See P. Parish and report of discussion, *C.T.J.*, 1926, **79**, 131, and W. H. Ibbotson, *Ind. Chem.*, 1929, v., 267.)

Studies of the radio-active disintegrations of uranium are said to indicate that the ultimate product of every series is lead.

Investigations of metallic lead as obtained from radio-active minerals —that is, minerals containing uranium and radium—have led to the view that there are at least three isotopes—including the ordinary type as found in non-radio-active minerals, and another produced by the decomposition of uranium, this radio-active form showing a slightly higher (0·05° C.) melting-point than that of ordinary lead; doubt, however, has been thrown upon this matter by more recent work. Ordinary inactive lead is stated to acquire radio-active properties by exposure to sunlight.

The density of the uranio-lead was originally reported as below that of the ordinary metal, as also its atomic weight (206). A specimen of lead prepared from a Norwegian *thorite* (from Langesundfiord), examined some years ago (containing 30·1 per cent. thorium, 0·45 per cent. uranium, and 0·35 per cent. lead), appeared to have an atomic weight of 207·77, the highest value then assigned to this element; while another prepared from Ceylon thorite gave the atomic weight of 207·74 (Soddy and Hyman). Since then an atomic weight of 206 (approximately) has been assigned to pure uranium lead (Richards and Hall, *J. Amer. C.S.*, 1926, xlviii., 704), while B. Perrette-Montamat has recently described two samples, one from galena with an atomic weight of 207·2, and another from pitchblende with an atomic weight of 206·14 (*B.C.A.*, 1929, A, 233); and Baxter and Bliss still more recently have determined it as 206·01 as contained in uranium lead extracted from Swedish kolm (*B.C.A.*, 1931, A, 279).

These matters cannot be regarded as definitely settled, and more exact refining processes and delicate methods of analysis are required to clear up the existing doubt as to the existence of distinct metallic leads. (See Isotopes and Transmutation.)

LEAD (*Continued*)—

Lead is a heavy, bluish-white metal, very soft in character, but not very ductile or tenacious, and it readily tarnishes upon exposure to the air. Owing to its soft character it is easily worked, and it is employed very largely for lining wooden tanks and drums, making water-pipes, gutters, roofing, shots, etc., also in the manufacture of white-lead and various alloys. It can be hardened by alloying it with a small proportion of metallic antimony or sodium. It is reported that lead filings, made with a coarse rasp, sprinkled on the threads of piping and held together by the cutting oil remaining on the threads, makes a better joint than that obtainable by the use of white-lead; also that lead may be "burned" to steel surfaces without any medium. The uses of lead and its alloys in chemical plant construction are dealt with by S. J. Tungay (*C.T.J.*, 1927, **80**, 252; *Chem. Age,* **19**, 27); the "Corrosion of Chemical Lead," by D. W. Jones (*J.S.C.I.*, 1928, **47**, 161 T); and the "Welding of Lead and its Alloys," by E. B. Partington (*C.T.J.*, 1931, **89**, 399).

Tree-lead and "spongy lead" are names given to that form of the metal resulting from the electrolysis of a lead solution (in arborescent crystalline form at the negative electrode). It can also be obtained by deposition on a bar of zinc placed in an aqueous solution of a lead salt.

Type-metal consists, in part, of lead (alloyed with antimony and tin), and lead is also used in the manufacture of *fusible metal* and *pewter; solder,* as used by plumbers and tin-plate workers, is a mixture of lead and tin in proportions varying with the particular applications to be made of it; whilst so-called *pot-metal* is an alloy of lead and copper. (See Alloys.)

White-Lead, which is used so much in compounding paints and putty, is a mixture of lead carbonate and hydrated lead oxide.

Of the various processes for making white-lead, the oldest and most extensively used is the so-called Dutch process, which depends upon the use of acetic acid in association with moist air and carbon dioxide. The lead, prepared in a way to present as large a surface as possible by being cast into rough gratings or grids, is placed on pots over a bed of spent tan-bark, acetic acid of 3 to 5 per cent. strength being placed in the pots. The acid is slowly vapourized by the heat of the fermenting tan, and this, acting upon the lead, forms a compound basic acetate, which undergoes further changes by the carbon dioxide evolved from the fermenting tan, and the action of air and moisture, finally resulting in the production of white-lead of commerce ($2PbCO_3,Pb(HO)_2$).

There is an electrical process of producing white-lead in which an aqueous solution of sodium acetate is electrolyzed between an anode of lead and a cathode of iron or copper separated by a diaphragm, while carbon dioxide is bubbled in at the cathode. The anolyte contains a small quantity of sodium carbonate or lead acetate and the catholyte a soluble carbonate or hydroxide. Acetic acid is set free at the anode and becomes lead acetate; sodium hydroxide produced at the cathode is carbonated by the carbon dioxide, and by interaction of these

LEAD (*Continued*)—

products white-lead is formed and the sodium acetate is recovered. (See *Ind. Chem.*, 1931, vii., 172.)

White-lead paint has unsurpassed covering power and may be prepared by grinding the dry white-lead in linseed oil or oil and turpentine admixed. It can also be made from the wet pigment by first of all grinding the dry base in water, thus obtaining a paste retaining from 40 to 60 per cent. water, which is subsequently well mixed by agitation or grinding with slightly heated refined raw linseed oil. The oil replaces the water, which rises to the top after settlement and can then be drawn off, leaving only a few tenths of 1 per cent. in the paste, which is again thoroughly ground. (See *C.T.J.*, 1925, **76,** 728.) With respect to white-lead poisoning, an amount greater than 2 grms. per day is viewed as dangerous for a man to absorb. No plumbiferous vapour is given off from lead paint; the danger arises from inhalation of the dust when paint is rubbed down dry, and this can be obviated by use of wetted water-proof sandpaper. (See Turpentine.)

A promising line of improvement in the manufacture consists in the employment of mechanical means for agitating the metallic lead in finely comminuted form in the presence of carbon dioxide and dilute acetic acid, the mass being kept always moist by careful addition of the liquid reagent.

Among many other processes for making "white-lead" is that of burning galena or other suitable material with coke and flux in a furnace, and cooling and collecting the white-fume product, which is used as a substitute for the ordinary article. B. S. White, of Joplin, Mo. (U.S.A.), has patented an improvement on this process (now in practical operation) in which molten lead is blown by means of compressed air in an atomized state with a mixture of sulphur dioxide, air, and natural gas, thereby producing a fume of super-sublimed white-lead consisting of 25 per cent. PbO and 75 per cent. $PbSO_4$ ($PbO, 2PbSO_4$), although the chemical composition of the product may be changed within certain limits at the will of the manufacturer. This product is alleged to be equal or superior to the basic carbonate for some purposes, and can be more particularly used in making ready-mixed paints.

Mixed with boiled linseed oil, white-lead makes a useful cement for pipes, glass cisterns, etc. Copies of specifications in respect of genuine white-lead, dry and paste, can be obtained from the B.E.S.A. (See *C.T.J.*, 1925, **76,** 33; Paints and White-lead (p. 987).)

Lead Compounds—Five oxides of lead are known, all of which are insoluble in water (Pb_2O, PbO, Pb_2O_3, Pb_3O_4, and PbO_2), but of these the PbO (litharge) and the Pb_3O_4 (red-lead) are the more important. The sesquioxide (Pb_2O_3) is converted into yellow monoxide when heated in air to 400° C.

A **Lead Hydroxide** of indefinite composition, but approximating to $2PbO.H_2O$, is produced in the form of a white, bulky precipitate by adding an alkaline hydroxide solution to one of a lead salt.

Lead Monoxide (PbO) is known in red and yellow forms (being poly-

LEAD (*Continued*)—

morphic modifications). (See M. Applebey and H. Powell (*J.C.S.*, 1931, p. 2821).) It is commonly prepared by strongly heating the metal in air, or by roasting nitrate or carbonate of lead. Under the name of *litharge*, it is used in the manufacture of certain qualities of glass and pottery, acid-resisting cements, lutes, and lakes, and in connection with that of oils, varnishes, and the leather and tanning trades.

Lead Dioxide (**Peroxide**) is a brown, crystalline body prepared amongst other methods by addition of calcium hypochlorite to an alkaline emulsion of lead hydroxide. By combination with alkalies, so-called plumbates are produced, such as potassium plumbate (K_2PbO_3) and calcium plumbate ($CaPbO_3$). The dioxide finds use as an oxidizing agent. It decomposes into red oxide and yellow monoxide at 300° in a vacuum.

Red-Lead (**Minium**) ($2PbO,PbO_2$ or Pb_3O_4) results from the prolonged heating of the monoxide in contact with air at about 450° C., and is a scarlet-coloured powder, which varies to some extent in colour and composition as prepared for commercial uses, containing as it does varying proportions of other oxides of the metal. (See *C.T.J.*, 1928, **83,** 71, and A. Junk (*B.C.A.*, 1929, B, 103).) It also occurs in natural deposits and is largely used in the manufacture of ceramics, flint glass, for making a useful cement in admixture with boiled oil, and as a pigment. (See C. E. Gelling on "Highly Dispersed Red-Lead" (*C.T.J.*, 1929, **85,** 78); and J. A. Darbyshire on "X-Ray Examination of Lead Oxides" (*J.C.S.*, 1932, p. 211).)

Lead Chloride ($PbCl_2$) is a white, crystalline substance, which is precipitated in a curdy form from solutions of lead salts by the addition of hydrochloric acid or a solution of a chloride, and can be obtained by dissolving the monoxide or lead carbonate in hot hydrochloric acid, from which solution it crystallizes out on cooling in long lustrous needles. It is soluble in boiling water (1 part in 25 parts).

A hydrated oxychloride, known as "Pattinson's white-lead," is obtained by heating lead chloride in air, and has a composition approximating to $PbCl_2,PbO,H_2O$.

Lead Sulphate ($PbSO_4$) is a white, insoluble body produced as a by-product in the manufacture of aluminium acetate (for use in waterproofing tarpaulins, etc.), and also results from the precipitation of lead salts in solution, by sulphuric acid or solution of a sulphate; it is used in compounding paints.

Lead Nitrate ($Pb(NO_3)_2$), a crystalline substance, very soluble in water, is made by dissolving litharge in nitric acid, and finds industrial applications as a mordant, in pigment compounding, etc.

Lead Iodide (PbI_2) is a beautiful yellow insoluble compound used in photography, bronzing, printing, etc.

Lead Sulphide (PbS) is a black compound found native as *galena*, and can be prepared by the action of hydrogen sulphide upon solutions of lead salts. It is insoluble in water, and used in ceramics.

LEAD (*Continued*)—

Lead Chromate (**Leipzig Yellow**) ($PbCrO_4$), found in mineral form as *crocoisite,* is a beautiful chrome-coloured insoluble pigment; used also in match-making. (See A. W. C. Harrison on "Lead Chromate Pigments" (*B.C.A.*, 1932, B, 117) and Chrome Yellows.)

Lead Acetate (**Sugar of Lead**) ($Pb(C_2H_3O_2)_2.3H_2O$) is a white, crystalline, poisonous salt, soluble in water; it becomes anhydrous when heated to 75° C., and is made by the action of acetic acid on litharge (PbO). It is used in dyeing and printing cotton goods, in varnish-making, the enamel industry, and medicine, and is prepared commercially in a number of grades of varying colour (white, grey, and brown) and purity. There are other acetates—viz., the monobasic salt ($Pb_2O(CH_3COO)_2$) and the tribasic ($Pb(C_2H_3O_2)_2 2PbO.H_2O$), both of which find industrial applications, the last named being used in weighting silk and textile printing.

Lead Antimonate (**Naples Yellow**) ($Pb_3(SbO_4)_2$) is insoluble in water, and is used as a pigment, also for staining glass and china ware.

Lead Arsenate ($Pb_3(AsO_4)_2$) is a white, insoluble, crystalline body used in compounding insecticides and fungicides. It is stated that the commercial material may contain two compounds—viz., lead hydrogen arsenate, $PbH(AsO_4)$, and a basic arsenate ($Pb(PbOH)(AsO_4)_3H_2O$). The most widely used procedure for making this compound is that in which lead oxide is suspended in a weak solution of arsenic acid with a small amount of nitric or acetic acid as a catalyser.

Lead Borates—The various borates of lead that have been described appear to be basic substances of varying composition. One such is the compound formulated as ($Pb(BO_2)_2H_2O$), which is insoluble in water and used in the varnish and paint trades as a drier.

Lead Carbonate ($PbCO_3$) is a white, crystalline powder, insoluble in water, used in paint-making and the ceramic industries.

Lead Oleate ($Pb(C_{18}H_{33}O_2)_2$) is a white, unctuous substance, soluble in alcohol, ether, benzol, and turpentine, used in making certain varnishes and lacquers and as a paint drier.

Lead Silicate ($PbSiO_3$) is a white, crystalline, insoluble compound used as a glaze in ceramics and for fireproofing fabrics.

Lead Cyanide ($Pb(CN)_2$) is used in metallurgy.

Lead Azide ($Pb(N_3)_2$), prepared by precipitation from a mixture of solutions of sodium azide and lead nitrate or acetate, is used as a fulminating or detonating agent in preference to fulminating mercury, since it contains more nitrogen, and is a better initiator, although not so sensitive to blows or percussion. It detonates at 327·5° C., whereas fulminating mercury detonates at 215° C. It is also used as a priming agent for fulminates, and is comparatively safe when in a state of fine division, although large crystals are very dangerous. (See Garner and Gomm (*J.C.S.*, 1931, p. 2123); F. Miles (*Ibid.*, p. 2532); and Azides.)

LEAD (*Continued*)—

Lead Resinate, prepared by heating a mixture of lead acetate solution and rosin oil or resin, is used as a varnish drier. **Lead Stearate** ($Pb(C_{18}H_{35}O_2)_2$), made from lead acetate and sodium stearate, is also used as a drier. **Lead Aluminate** (PbO,Al_2O_3)—A useful white pigment. (See Paints.)

All lead compounds are poisonous, but lead glazes of low solubility as used in the pottery industry are practically innocuous.

LEAD ASHES—The skimmings due to oxidation in melting down lead.

LEAD PLASTER—A mixture of lead soaps of fatty acids, prepared by heating olive oil with litharge or by heating a solution of lead nitrate with sodium linoleate; used in medical practice as an external application and as a drier in varnish-making. (See Diggs and Campbell on "Chemistry of Lead Soaps" (*B.C.A.*, 1928, B, 717).)

LEAD TETRA-ETHYL—See Motor Spirit.

LEATHER CLOTHS are made by coating textile fabrics with various mixtures of materials. The various makes include "Fabrex," "Fabrikoid," "Pegamoid," "Rexine," "Stipplex." (See also Tanning.)

LEATHER JAPANNING—See Tanning.

LEAVEN is really bread which has commenced to decompose by a sort of fermentation, but its use for leavening fresh bread has been superseded by the general use of yeast. (See Yeasts.)

LEBLANC PROCESS—See Sodium Compounds (p. 828).

LECITHIN—A mono-amino-monophosphatide; also represented as a triglyceride containing two complex acyl groups, derived from stearic, oleic, and other acids, the third hydrogen being replaced by a choline phosphoric group. Some synthetic lecithins have been prepared, including the stearic and palmitic compounds. (See "Lecithin as an Emulsifier," by R. M. Woodman (*J.S.C.I.*, 1932, **51**, 95 T); Brain Matter and Eggs.)

LEGAL MATTERS—In addition to the many Acts of Parliament concerning the alkali and other trades and arts, the Factory Acts, Employers' Liability, Acts affecting labour, merchandise marks, trademarks, patents, health, and adulteration of foods and drugs, etc., see pamphlet entitled "Some Aspects of the Law affecting Chemists," by E. J. MacGillivray (Inst. Chem.); "Copyright: with Special Reference to Scientific Papers and Publications," by E. J. MacGillivray (Inst. Chem.); "Chemistry and the Law," by J. Whitehead (Inst. Chem.); *Chemists and the Patent Laws,* by Horatio Ballantyne (Inst. Chem.); *Notes on Contracts of Service,* by G. S. W. Marlow (Inst. Chem.); article on "Medical Patents" (*Chem. and Ind.*, 1930, **49**, 573); E. Potter on "Patents" (*Chem. and Ind.*, 1930, **49**, 1096); *Law and Industry,* by G. S. W. Marlow (Baillière, Tindall and Cox); and Patent Law.

LEGUMIN (**Vegetable Casein**)—The distinctive nutritive protein constituent of peas, beans, and lentils, amounting to about 25 per cent. calculated on the dried products. (See Albumins and Proteins.)

"LEIPZIG" YELLOW—Lead chromate. (See Chrome Yellows.)

LEMON GRASS OIL—There are several varieties, including the East Indian and the West Indian, the parent plant being the *Cymbopogon flexuosus*. The Ceylon and Straits Settlements oil comes from the *Andropogon citratus*, and is stated to contain from 21 to 38 per cent. citral, while the Malabar and Cochin oils from the *C. flexuosus* plant has a sp. gr. 0·895 to 0·097, opt. rot. +1° to −5°, ref. ind. 1·4825 to 1·4885, and contains from 70 to 85 per cent. citral. (See Verbena Oil.)

LEMON OIL—A pale yellow, limpid liquid of lemon odour, expressed from the peel of the *Citrus limonum* (N.O. Aurantiacea) to the extent of about 1 per cent.; containing about 90 per cent. limonene, associated with pinene, citral (about 4 per cent.), and citronellal; sp. gr. 0·858 to 0·862 at 15° C., opt. rot. +60 to +64 at 20° C., and ref. ind. 1·473 to 1·476 at 25° C. It is soluble in alcohol, ether, etc., and used in perfumery, also for flavouring, and compounding some beverages. Lemon juice exhibits anti-scorbutic properties and is a remedy against scurvy, possessing as it does the water soluble vitamin agent C. (See F. La Face on "Mechanical Processes for Extracting Oil of Lemon," *B.C.A.*, 1931, B, 318; Limonene and Vitamins.)

LENTILS—Seeds of the leguminous annual plant *Ervum lens*, from which a flour can be prepared. There are several varieties extensively cultivated in European countries.

LEPIDOLITE (Lithia Mica) [$(LiK)_2,Al_2O_3,(Fe,OH)_2 3SiO_2$]—A Moravian purple mineral, of crystal system, No. 5, and sp. gr. 2·8 to 3·0 containing lithium and aluminium in combination as silicates. (See S. Iimori and J. Yoshimura (*B.C.A.*, 1927, A, 129), and J. Jacob (*B.C.A.*, 1929, A, 45); also Cæsium, Mica, Potassium, and Rubidium.)

LEUCINE (Amino-Caproic Acid) ($C_6H_{13}NO_2$)—A decomposition product of albuminoid bodies, generally accompanying tyrosine in the animal economy. It forms glistening plates and closely resembles glycocoll.

LEUCITE—A mineral double silicate of aluminium and potassium ($K_2O,Al_2O_3.4SiO_2$), of rock character, used in Italy as a source of potassium compounds; also for the preparation of "Rhenania phosphate," by heating with phosphatic minerals to 1,250° C., the product being an alkaline fertilizer soluble in citric acid, etc. It is found in crystal systems, No. 1 and No. 4, having a sp. gr. of about 2·5, and can be separated electro-magnetically from the basaltic (laval) masses of volcanoes which contain it. It is treated with hydrochloric or nitric acid, the products being silica and a solution of aluminium and potassium chlorides or nitrates. (See *C.T.J.*, 1931, **88**, 262; *Ind. Chem.*, 1927, iii., 87 and 512; Aluminium, and Potassium (p. 725).)

LEUCO-BASES—See Dyes.

LEUCOCYTES—See Bacteria and Phagocytes.

LEVIGATION—The reduction of lumps and hard parts of substances to pulverulent form by grinding in water or other liquid. (See Leaching.)

LEVULINIC ACID—See Propionic Acid.

LEVULOSE (**Lævulose**) ($C_6H_{12}O_6$) (**Fructose**)—A crystalline form of glucose which results along with dextrose from the action of dilute acids upon sucrose (cane sugar). It turns the plane of polarization of a ray of light to the left. Many farm products are suitable sources of production, including the drainings from cane sugar, and a process has been described in the U.S.A. for its manufacture from the tubers of the artichoke, which contain from 10·7 to 12·4 per cent. (after conversion). When oxidized with chromic acid mixture, it is stated to yield an appreciable amount of formaldehyde. (See Carbohydrates, Fructose, Invertase, and Saccharoses.)

LEWIS-LANGMUIR THEORY—Concerns the hypothetical structure of atoms. (See "Octet" Theory and Valencies (p. 946).)

LEWIS' OCTET THEORY—See "Octet" Theory and Valencies.

LEY—See Lye.

LICHENIN (**Moss Starch**)—Present in many lichens—*e.g.*, Iceland moss (*Cetraria islandica*). Lichenin is stated to be depolymerized when heated in glycerol at 240° C. to lichosan ($C_6H_{10}O_5$). (See H. Pringsheim and others (*B.C.A.*, 1925, B, 954).)

LICHENS—Many species of these plants are used for food and in dyeing. In the varieties *Rocella, Lecanora,* and *Evernia prunastris,* lecanoric and evernic acids occur; these so-called depsides are related to gallotannin. The vegetable colours litmus and archil are depsides obtained from lichens. A compound named lichenol, of m.p. 72° to 73° C., is reported to be the chief constituent of oak-moss (*Evernia prunastri*) oil. (See Asahina and Ihara on "Lichen Substances" (*B.C.A.*, 1929, A, 818); Robertson and Stephenson on "Lichen Acids" (*J.C.S.*, 1930, p. 313); also Fungi and Orcinol.)

LICORICE—See Liquorice.

LIEBIG'S BULBS—See Organic Analyses.

LIEBIG'S CONDENSER—See Retorts.

LIFE—See Chemical Interactions, p. 173.

LIGHT—Light in nature is chiefly derived from the sun, but is also furnished by other heavenly bodies. The glow-worm and the firefly have the power of giving out light in the darkness, and, as is well known, decaying animal matter exhibits a pale phosphorescent light.

The production of light by forms of animal life such as fireflies (*Pholas dactylus*, etc.) is stated to be due to the burning by oxidation of a substance named *luciferin* in presence of a catalyst called *luciferase,* and the oxidation product (oxyluciferin) can be readily reduced again to the original substance.

The fish known as *Malacocephalus lævis* exhibits light-producing

LIGHT (*Continued*)—

properties, while in the case of *Renilla* it is thought that the phosphorescence produced at night by stimulation is under the control of the nerve-net of the animal.

The phosphorescence of the sea is generally attributed to light given out by countless bacteria and other low forms of life present in the water.

When a current of electricity is sent through an electric lamp it encounters a resistance in its passage through the imperfection of the conducting filament, and is in consequence partially transformed into light and heat.

Lightning is a form of light connected with electric discharges from the clouds. Light can also be produced by chemical means, many substances, such as phosphorus, magnesium, strontium, and sulphur, emitting light of different degrees and shades when burned in the air.

Lophin ($C_{21}H_{18}N_2$), a substance obtained from amarin and hydrobenzamide by dry distillation, exhibits phosphorescence at and below $+10°$ C. in presence of oxygen and alkaline matter.

A green glow is observed when white phosphorus undergoes oxidation by exposure to the air, while phosphorescence is also exhibited by calcium sulphide, barium nitrate, and zinc sulphide in the dark after exposure to light—particularly sunlight. This property is utilized in compounding luminous paints, but it would appear that the pure compounds do not exhibit it, and that it is due to traces of certain heavy metals, such as bismuth, lead, copper, molybdenum, tungsten, uranium, etc. A suggestion has been made that this kind of phosphorescence is due to the emission of electrons, which return to the molecules from which they emanate during darkness. H. A. Taylor thinks that phosphorescence is possibly a photo-chemical rather than a thermal process (*B.C.A.*, 1927, A, 187). The term includes photoluminescence and cathodoluminescence (associated with subsidiary phenomena), the phosphorescent emission being the radiation of energy during the change of the molecules from the activated to their original state—that is, the state in which the "phosphore" existed before being brought into a state of higher energy by the absorption of radiant energy (Baly, *Chem. and Ind.*, 1928, **47,** 916).

Luminescence is frequently observed during the electrolysis of certain solutions and in gases under excitation by electric discharges, while many substances such as salts or silica when wet show a bright blue luminescence when irradiated by a mercury vapour lamp through a screen excluding the visible region (J. Ewles, *Nature,* 1930, **125,** 706). In all such cases, probably the emission of light is electrical in essence. (See F. Schmieder on "Economy Co-efficients of Phosphorescent Substances" (*J.C.S.*, October, 1925, II., 931), and H. J. Emeléus (*J.C.S.*, 1929, p. 1733) on "Light Emission from certain Phosphorescent Flames.")

A solution of *p*-bromophenyl magnesium bromide in ether (prepared by the Grignard reaction between 2·4 grammes of magnesium and 23·6 grammes of *p*-dibromobenzene in 130 c.c. of dry ether, with a

LIGHT (*Continued*)—

little iodine) exhibits luminescence observable in daylight when shaken in a test-tube in an atmosphere of oxygen; the oxidation of various organic bodies, including pyrogallol and certain dyestuffs, gives rise to luminescence, or, as it is sometimes named, "cold light"; while eosin dissolved in anhydrous glycerol shows a fluorescence.

By reducing rubidium sulphate in a graphite boat with hydrogen at about 650° C. a phosphorescent mixture of sulphate and sulphide results, the light emitted being a bluish-red. Chloroazoimide gas heated while passing through a capillary tube suffers decomposition, producing a red glow and exciting fluorescence in the glass.

Intense phosphorescence can be produced by the presence of certain organic substances in partially dehydrated boric acid upon exposure to the light of a mercury lamp or iron-carbon arc.

Light can be produced by the rubbing together of sugar crystals or quartz, or when quartz is rubbed by any material harder than itself, such as topaz or sapphire or water-worn pebbles of corundum. It is also emitted during the act of crystallization of certain salts from their solutions, as, for instance, that of arsenious oxide from supersaturated solutions.

In the ordinary combustion of fuel (wood and coal) light is also produced; in fact, combustion of organic matter is always attended with production of more or less light and heat, whilst flame can be described as gas heated to such a temperature (incandescence) that it emits light as well as heat.

According to David and Davies (*Nature*, 1930, **125,** 127), the intensity of the luminosity in exploded gas mixtures is completely dependent on temperature.

When a stream of oxygen mixed with hydrogen is ignited, the mixed gases burn without giving out any sensible amount of light; but if the jet be directed upon a piece of lime, the most brilliant light, or so-called *oxyhydrogen limelight,* is produced so soon as the lime becomes hot. Another familiar instance of the power of solids to influence the light given out by flame is afforded by the so-called Welsbach mantle, in which the burning coal gas (which in itself would give what is practically a blue flame almost devoid of light) playing upon a surrounding mantle impregnated with certain mineral oxides develops an intense white light. (See Gas Mantles.)

Light is regarded by some physicists as electro-magnetic in character, and described as extremely short waves ranging from about half a millimetre in the infra-red to approximately a hundred thousandth of a millimetre in the extreme ultra-violet, while those approximating to 1,000,000th of a metre, caused by the oscillation of electrons of an electro-magnetic character, constitute a form of radiant energy. (See Radiation.)

Among other views, light has been described as not so much a thing as an effect, a *state* of matter—that is to say, illuminated matter, varying, of course, with the medium through which it is rendered evident, its revelation being dependent upon what are called undulations or vibrations similar to those of sound produced by blows upon metallic or

LIGHT (*Continued*)—

other bodies and by musical instruments. When a gong is hit by a hammer, it is thrown into a state of excitement or vibration and sound is produced. Sound will not travel in what is generally termed a vacuum. Its velocity in gases varies inversely as the square root of the density. It travels in air at about $\frac{1}{5}$ of a mile per second, in water at about 1 mile, and in steel 3 miles, and is always directly associated with the movements of particulated matter, but the precise nature of the sound, whether of wave or corpuscular nature, is not known. In a similar sort of way, when a gas is ignited or when a solid body (as in the case of the limelight) becomes heated in a flame of gas, light is given out in consequence of the burning gas being thrown, as is supposed, into a state of tremendous excitement or vibration. The light thus produced is quite distinct from the heat which acts as a first cause or incitement to its production. Hertz appears to have proved the identity of ordinary light with the larger electro-magnetic waves. (See Wave Lengths.)

Light travels at the rate of about 186,300 miles per second—and is only eight minutes in coming from the sun to the earth.

According to the theory of relativity, light (in common with heat) is both undulatory and corpuscular, and stated to be deflected by gravity; but against this last-named assumption it may be urged that it may be the extremely attenuated matter which can never be wholly eliminated from space—an absolute vacuum being practically unattainable—which suffers deflection, carrying the light rays with it, and thus accounting for the pressure it is alleged to exercise. (See Vacuum.)

The source of the light given out when magnesium or phosphorus is burnt in oxygen gas must be contained or locked up in these substances, as explained in the section on Force. As a matter of fact, heat always accompanies light, as in the sun's rays.

It has been recently demonstrated by experiment that speech can be transmitted by the agency of light.

Light is *reflected* when its rays fall upon a mirror—that is to say, it is thrown back at an angle—and may be thus made to show a brilliant spot upon a wall. Hearing by the agency of light (phototelephony) is described as a process of reconstruction of equivalent sounds at the receiving end, dependent on the action of photo-electric cells, the projected beam of light or "carrier" wave being suitably modulated in accordance with the vibrations constituting speech.

White light is said to be made up principally of seven colours, and there are several methods of obtaining white light by recombining the three primary colours—red, green, and blue. If a circular piece of cardboard be painted with the seven colours—violet, indigo, blue, green, yellow, orange, and red—in equal sections and made to rotate, or spin quickly, the several colours disappear to the eye, and the whole face of the disc appears to be white. Colour admits of infinite gradation, and depends on the wave-lengths of electro-magnetic oscillations. Any colour can be matched by a mixture of one suitable spectrum colour and white light. (See Colour.)

LIGHT (*Continued*)—

In daylight the proportion of red-orange rays is about 21½ per cent., and that of blue-violet 46½, whereas in the light from a half-watt electric lamp the proportions are respectively 54½ and 13 per cent. The Sheringham daylight lamp throws the light from an electric lamp upon a shade coloured with certain pigments which absorb the excess of red-orange and give out as much as possible of the blue-violet rays, the connection of artificial light to daylight being dependent upon this process of eliminating rays in increasing amounts from the blue to the red end of the spectrum. The daylight lamp is used commercially in the matching of colours where such matching was previously impossible in the ordinary electric lamp-light.

The "Macbeth Lamp" is designed to obtain a view of colours as sure as by best daylight, the illumination at the desired point being ten to fifty times greater than ordinary interior artificial lighting intensity. It is produced by ordinary clear glass incandescent lamps, the light being corrected by passage through special filters, of which a series is provided, so as to enable any natural daylight-equivalent to be employed.

Light also exercises a considerable influence in respect of many chemical changes, particularly those which take place in animal and vegetable tissues. The green parts of plants absorb carbon dioxide gas from the atmosphere under the influence of solar light, the carbon being assimilated or fixed in their tissues by chemical changes, oxygen being at the same time restored to the atmosphere. These changes, which materially assist in preserving the uniformity of composition of the air, do not take place when the light is excluded. Vegetable matter cannot make its green colouring-matter (chlorophyll) without light, and so celery, seakale, etc., are grown in a blanched state by being kept in the dark. (See Photo-Catalysis and Vegetation.)

A mixture of chlorine gas with hydrogen gas in certain proportions undergoes no chemical change in the dark, but if exposed to sunlight, the two gases enter into combination with explosive violence. The union of hydrogen and chlorine in the presence of moisture when exposed to the light of a 100 candle-power Osram lamp takes place within twelve minutes, but when the gases are carefully desiccated there is no sign of combination after two hours. Under the influence of ultra-violet radiation from a 15-20 amp. arc light, bromine dropped into toluol instantly reacts therewith, hydrobromic acid being copiously evolved, whereas in ordinary electric light no reaction occurs.

Again, the art of photography depends upon chemical changes brought about on the prepared (sensitized) paper or plate by the direct action of light upon chemicals placed on their surfaces, solar light having the power of causing decomposition of the oxide, chloride, nitrate, or bromide of silver, for example, when these substances (with which their surfaces are variously treated) are exposed to it. (See Photo-Chemistry.)

The bleaching of linen and other goods by exposing them to moisture and air is another well-known illustration of the influence of light

LIGHT (*Continued*)—

in effecting chemical changes. Fugitive colours, however, will not fade even in a strong light if completely protected from oxygen (air) and moisture.

Many chemical reactions are accelerated by light, and these effects are more marked in the presence of ultra-violet light than in the presence of light of shorter wave-length. Radiant heat, light, and electricity are similar from a purely physical standpoint, and they produce similar chemical changes. (See report of lecture by M. Bodenstein on the "Chemical Action of Light" (*Chem. and Ind.*, 1930, **49,** 139).)

Polarization—A Nicol prism (analyser) composed of Iceland spar—pure crystallized calcium carbonate—split along a diagonal plane and then cemented together again with Canada balsam, gives a pencil of light, the vibrations of which are in one plane only, and light so obtained is said to be polarized. Many liquids exhibit optical activity and effect the rotation of a ray of polarized light when placed in a column between two Nicol prisms in a suitable instrument. Polarimeters (polariscopes) are the various instruments used to measure the angle through which the polarized ray is turned to the right or to the left. Substances which rotate the ray of polarized light to the right are termed dextro-rotatory, and those which rotate it to the left are termed lævo-rotatory. (See Invertase.)

Spectroscope—This is an instrument by means of which the light emitted by strongly heated substances can be examined. It is constructed of one or more prisms by which the coloured rays are separated and dispersed when light is made to pass through them. This analysis or splitting up of light into the different colours of which it is constituted furnishes what is termed the prismatic spectrum, each colour having its own peculiar refrangibility ranging from the red rays, which are the least refrangible, to the deep violet, which are most refrangible, at the other end of the rainbow. The term spectrum also includes the invisible regions on both sides. A spectrum is produced by passing light through a grating of glass having closely ruled lines on it. (See Wave Lengths.)

Various chemical salts, when heated in the blow-pipe or nearly colourless Bunsen-burner flame, impart characteristic colours indicative of their nature, but where mixtures are concerned the indication is lost on account of the merging or blending of the various colours which takes place. Sodium compounds give a yellow colour to flame; potassium salts tinge the flame purple; whilst lithium salts communicate a crimson-red colour. The colour given by the salts of rubidium and cæsium is indistinguishable by the naked eye from that of potassium compounds, but when these coloured flames are examined through the telescope (forming a part of the instrument under description), the spectrum affords an easy and assured method of diagnosis, inasmuch as the chemical salts under examination furnish distinct bright bands of light. Sodium compounds give a distinct line or group of lines in the yellow, lithium gives one band in the red and another in the yellow, and potas-

LIGHT (*Continued*)—

sium also gives two bands (one in the deep red and another in the violet), and when mixtures are examined, the individual or distinctive bands are all respectively revealed.

This method of detection is so delicate that so small a part as $\frac{1}{180000000}$ grain of sodium salt and $\frac{1}{60000000}$ grain of lithium can be detected.

Characteristic spectra are afforded not only by substances which give colour to flame, but by every elementary body when heated to the degree at which its vapour becomes luminous.

Optical spectra, it is alleged, have their origin in the vibrations of the electrons forming the constituents of the atoms of matter, and the current views of atomic structure largely depend upon investigations concerning them, some modern physicists having been enabled, it is claimed, to show how the electrons are spaced round the nuclei of the various atoms. Again, it is stated that the mass-spectograph has enabled Aston to weigh the nuclei, etc. Whether, however, the inferences drawn from the observed phenomena justify the speculations based thereon time alone will show.

Many of the elements were discovered by the use of spectrum analysis, including cæsium, rubidium, thallium, indium, helium, and gallium, before anything was known of their chemical properties.

The instrument in its simplest form consists of a prism fixed upon a stand placed in line with a hollow tube provided with a slit or shutter at the end opposite to which the flame is placed for examination. The light under examination passing along this tube by way of the slit is received upon the prism through a lens fixed in the tube called the collimator, which renders the rays parallel, and the refracted rays from the red end to the blue end are received by the observer using the telescope, which is placed in such a position that the bent rays fall upon its lens, and are magnified by it. Otherwise, instead of using the eye, it may be replaced by a photographic plate on which the spectral bands are thus recorded.

"Emission spectra" can be produced in a number of ways—viz., by the use of flame such as that of a Bunsen lamp in respect of the more or less volatile metallic salts; or by the electric arc, which furnishes a much higher temperature, the spectrum being obtained by placing the substances to be examined into the arc between the carbon poles; or by means of the sparks from an induction coil made to pass between small poles of the substance, or discharged through gases—a method which can be applied to solutions; or by the use of cathode streams for the production of phosphorescence in solid substances.

The relation between the powers of emission and those of absorption for rays of the same wave-lengths is constant for all bodies at the same temperature.

Organic solutions were first examined by photographing the spark spectrum of an alloy of tin, lead, cadmium, and bismuth, as obtained through a solution of the subject under examination.

The bright yellow sodium lines are made to appear as dark lines

LIGHT (*Continued*)—

or spaces by allowing the rays of a white light (like that of the oxy-hydrogen flame or an incandescent platinum wire) to pass through a flame coloured by a sodium compound, and then to fall upon the slit of a spectroscope, because the yellow flame absorbs the same kind of light as it emits, and similarly each substance in the vaporous state has the power of absorbing the same rays as it emits, or being opaque to same. This accounts for the dark spaces or so-called "Fraunhofer" lines observed in the solar atmosphere, these being, as is believed, bright lines reversed, and indicative, therefore, of the presence in the sun's atmosphere of those substances which are capable of yielding the coincident bright lines, including iron, sodium, calcium, magnesium, chromium, barium, copper, zinc, hydrogen, and nickel.

The length of the spectrum that can be seen by the human eye extends from 3,900 to 7,600 angström units.

By the investigation of emission and absorption spectra, using a variety of appliances adapted to the many different substances requiring examination, it has been found possible to acquire a very definite knowledge of the constitution of the sun's atmosphere, the fixed stars, and the so-called nebulæ (which are regarded as masses of glowing gases). Working with a very large telescope, J. S. Plasket has obtained evidence of the presence of calcium and sodium vapours in the spaces between the stars and the earth, and some 58 elements have been identified in the solar spectrum, although the spectrum tells nothing respecting the composition of the body bulk of the sun and stars. "The hotter the star the simpler the spectrum, until at the highest temperature we obtain practically nothing but the lines of hydrogen or helium" (H. Dingle).

These various methods have also been turned to account for the identification of precious stones, dyes, and colouring matters; the detection of alum in wines and fruit juices, blighted wheat in flour, and blood-stains; the estimation of alkaloids, the detection of minute quantities of metals, the valuation of indigo samples, the examination of essential oils, sugar analysis, etc. The spectroscope has also proved of great value in the investigation of many organic compounds, radical groups such as CH_2, CH_3, NH_2, C_6H_6, HO, etc., all giving characteristic absorption bands. (See "Molecular Spectra and Molecular Structure" (The Faraday Society, London); F. Twyman on "Metallurgical Spectrum Analysis" (*Chem. and Ind.*, 1927, **46**, 284 and 307); same author on "Absorption Spectrography" (*Chem. and Ind.*, 1930, **49**, 535, 556, and 578); Optophone (under heading of Selenium); *A Treatise on Light*, by R. A. Houston (Longmans, Green and Co., London); and *Introduction to Physical Optics*, by J. K. Robertson (Chapman and Hall, 1930).)

Mass Spectrography—The mass spectrograph is an instrument by means of which the charged atoms in a beam of positive rays are stated to be sorted out according to their weights by the use of magnetic and electric fields, so that they strike a photographic plate at different points. In this way a mixture of atoms of differing weights give a series

LIGHT (*Continued*)—

of focussed lines (mass spectrum), enabling their relative weights to be calculated from the positions of the lines. It is in this way that the so-called isotopes are supposed to be identified, chlorine, for example, being thus viewed as a mixture of atoms of weights 35 and 37. (See F. W. Aston, Boyle Lecture of 1924 on "Mass Spectra and Isotopes" (Oxford University Press), and *Phil. Mag.*, 1925 (vi.), xlix., 1191-1201.)

There are, however, some exceptions to the calculated numbers and inferences, and a good many gaps exist in the order of atomic weights as thus calculated. In such investigations in which very minute quantities of materials are dealt with, the question of their absolute purity is of great importance, and they may possibly be contaminated with hydrogen, mercury from the vacuum pump, or other impurities associated with or derived from the apparatus or its atmospheric environment.

It is also of importance to observe that the results of these particular investigations give strong confirmation to the chemically determined atomic weights of the elements, so that isotopes cannot be viewed as fundamentally established. This consideration is strengthened by the fact that certain spectral lines at first attributed to certain new or unknown elements have been by further investigation proved due to known elements under special conditions. (See Lord Rayleigh's address to Section of Mathematical and Physical Sciences, British Association, 1929, as reported in *The Times*, July 25, 1929, p. 19; also Atoms. Elements, Isotopes, and Spectroscopy.)

LIGHT OILS—The commercial hydrocarbon products from light oils, including various qualities of benzol, toluol, xylol, naphtha, etc., have been standardized, and specifications are issued by the B.E.S.A. (See Coal (p. 207).)

LIGHTING—See Factory Lighting (*C.T.J.*, 1928, **83,** 422).

LIGHTNING—See Electricity (p. 289) and Light (p. 532).

LIGNIN—Lignin is supposed to result from dehydrating changes in the cellulose forming the original walls of living wood cells, so that the heart of a tree is composed largely of lignin as distinct from the soft, pithy living parts; the major part being in combination with polysaccharides.

The free lignin can be extracted by alcohol and the combined lignin by resolving ligno-cellulose into its constituents by heating with 4 per cent. sodium hydroxide at 10 atm. for one hour. This treatment is stated not to decompose the lignin, which can be precipitated by acidification and then extracted with alcohol. (See M. M. Mehta (*B.C.A.*, 1926, A, 209). Other modified methods are described by Freudenberg (with others) (*B.C.A.*, 1929, A, 1046) and Fuchs and Horn (*Ibid.*).)

H. Wislicenus (*B.C.A.*, 1925, **44,** B, 625) takes the view that lignin is not a chemical entity, but the product of a botanical (biochemical) process, including in its complex, colloidal polysaccharides, hexosans, pentosans, gums, calcium salts of pectic acid, etc., all more or less

LIGNIN (*Continued*)—

irreversibly fixed by adsorption, but still slightly admitting of extraction with water, the group of tannins and colouring matter belonging to the later stages of lignification. The lignin chemically described must be regarded as resulting from this complex by treatment, but it has been represented (as produced from straw) by various formulæ, including $C_{40}H_{46}O_{15}$,$C_{20}H_{22}O_7$, and $C_{40}H_{44}O_5$. Pine β-lignin has also been represented as $C_{19}H_{18}O_7$. (See C. Doree and E. C. Barton-Wright (*Chem. and Ind.*, 1927, **46**, 129); Bassow (with others) (*B.C.A.*, 1929, A, 1282, and 1931, A, 1278); and P. B. Sarkar on "Jute-Lignin" (*B.C.A.*, 1931, B, 1087).) Spruce lignin was later represented as $C_{40}H_{40}O_{12}$, and A. Friedrich has given the formula $C_{33}H_{36}O_{12}$ as that of a soluble lignin derived from pinewood (*B.C.A.*, 1928, B, 1119), and P. Klason has recently given α-lignin as $6C_{10}H_{12}O_4$ and β-lignin as $C_{92}H_{108}O_{38}$ (*B.C.A.*, 1929, A, 1428; 1930, A, 1025 and 1418; 1931, A, 1401; and 1932, A, 57). (See also H. Hibbert (with others) (*B.C.A.*, 1930, A, 1275, and A, 1418).)

Flax lignin has been represented by the formula $C_{45}H_{48}O_{16}$. According to W. J. Powell and H. Whittaker (*J.C.S.*, cxxvii., 132), the lignins from the various natural sources are derivatives of the same hydroxy compound, differing only in the number of methoxyl groups respectively contained.

M. Phillips gives the composition $C_{42}H_{40}O_{16}$ to the lignin obtained as described by him from oat-hulls (*B.C.A.*, 1930, A, 458).

Lignin can be obtained by the treatment of wood with 70 per cent. sulphuric acid, but a better result is said to be obtained by first of all saturating the powdered wood with a mixture of acetone and ethylic alcohol and treating the product with strong hydrochloric acid. The cellulose and other carbohydrates are dissolved and the lignin is left behind, amounting to some 28 to 30 per cent. of dry woods, representing the microscopic structure of the wood cells. A method of quantitative estimation of lignin in wood-pulp based upon the use of a mixture of phosphoric anhydride and hydrochloric acid has been described by H. Wenzl (*Analyst*, 1924, **49**, 543).

According to A. Foulon, lignin may be separated from cellulose by hydrolyzing wood with dilute (0·3 per cent.) sulphuric acid in concentrated acetic acid, the cellulose remaining almost unattacked. (See *B.C.A.*, 1925, B, 385, and K. Kürschner (*B.C.A.*, 1925, B, 912).)

It is said to be obtainable from straw by digestion with an alkaline carbonate, precipitation from the extract by acid, and purification by repeated solution in alkali and reprecipitation with acid. It is almost completely dissolved by digestion in 5 per cent. caustic soda solution at 170° C., and wood lignin is stated to yield protocatechuic acid by fusion with caustic potash, pyrocatechol being subsequently formed from it by elimination of carbon dioxide in presence of air.

When prepared from pine wood by treatment with 45 per cent. hydrochloric acid and subsequently distilled, furfurol (furfuraldehyde $[(CH)_3OC.COH]$) is obtained, being derived from an integral carbohydrate part of the lignin molecule—viz., arabinose—and when prepared

LIGNIN (*Continued*)—
by Kürschner's method it yields about 60 per cent. of its weight as a sublimate of vanillic acid with some vanillin at 200° C. (See Furfurol.)

In a study of the degradation products of lignin it has been shown that wood meal is converted almost quantitatively within a few days into products soluble in water by treatment with a mixture of acetic acid and acetic anhydride (1 : 1) containing 9 to 10 vol. of sulphuric acid (H. Friese, *B.C.A.*, 1930, A, 1169).

Lignin, by condensation with furfural and aromatic amines, has recently been used for the preparation of so-called synthetic resins (See also Cellulose and Wood (*Ind. Eng. Chem.*, March, 1931).)

LIGNITE—A brownish-black natural deposit allied to coal, occurring in many parts of the world, including Bovey Tracey in Devonshire, and of which great deposits near the surface of the earth are found in Germany, Greece, Northern Ontario and other parts of Canada, Australia, New Zealand, India, Burma, and the Malay Peninsula, while deposits in Holland and Italy have been largely worked since 1917. They usually contain from about 20 to 50 per cent. water, from 27 to 43 per cent. of carbon, generally disintegrate upon drying, and will not coke. They yield so-called paraffin oil upon distillation, while their calorific value is about half that of coal. The transformation of lignite into petroleum and benzol is said to be effected by treating the powdered substance with hydrogen gas under a pressure of 100 atm. at about 200° C., 5 per cent. hydrogen being required to obtain petroleum, and 10 per cent. for producing benzol. When mixed with tar oil, lignite is stated to be hydrogenated by the "Bergius" process in two stages, first under pressure, and this is repeated in presence of a catalyst at 450° C., and subject to a pressure of 200 kg., yielding 50 per cent. of motor fuel. (See Bergenization.)

The lignite from the Riebeck Montan Works yields 15 per cent. of a quality of bitumen which is soluble in hot benzene and 8 per cent. of another quality which is dissolved at a higher temperature, a large part of the extractives being identical in composition with so-called Montan wax. The insoluble part yields the major portion in a soluble form on heating with alkali in solution as so-called "humic acids," which are precipitable upon acidification of the alkaline extract.

The waxy substance, forming 82·4 per cent. of the bitumen from Rhenish lignite, is stated to contain myricyl alcohol and another alcohol termed bituminol ($C_{32}H_{66}O$ or $C_{32}H_{64}O$) in the ratio 1 : 5, together with acids like those of central German lignites—viz., carboceric acid ($C_{27}H_{54}O_2$) and Montanic acid ($C_{29}H_{58}O_2$) in ratio 1 : 1.

There is for each particular brown coal or lignite a temperature limit (usually between 300° and 400° C.) to which it may be heated, thus effecting a considerable chemical condensation in its cellulosic or humic constituents, steam and carbon dioxide being thus generated. This condensation constitutes a possible means of "up-grading" them, thus improving their fuel values.

Both brown coals and lignites are regarded by some as intermediate forms between peat and bituminous coals, while others think that brown

LIGNITE (*Continued*)—
coals have originated from vegetable debris different from that which in carboniferous times gave rise to our present bituminous coals. The pulverized form of lignites can be used under boilers for steam raising. (See article on "Lignite," by H. M. Langton (*Ind. Chem.*, 1931, vii., 415); "Chemical Constituents of Lignites," by J. Marcussow (*B.C.A.*, 1927, B, 898); D. Brownlie on "The Low Temperature Carbonization of Australian Lignite" (*Ind. Chem.*, 1928, iv., 284); R. Oda (*B.C.A.*, 1930, B, 973); W. Fuchs (*B.C.A.*, 1930, B, 800, and *Chem. and Ind.*, 1931, **50,** 644); Brown Coals, Coal, and Waxes (Montan).)

LIGNOCERIC ACID ($C_{24}H_{48}O_2$)—A member of the normal fatty acids, melting at 80° C., contained in many oils, including arachis oil.

LIGNUM VITÆ—The heart-wood of *Guaiacum officinale* or of *Guaiacum sanctum*; sp. gr. 1·336; is employed in the form of shavings, raspings, and sawdust for making medical decoctions, but more extensively for making taps and vessels, being hard, strong, and withstanding the action of many liquids better than ordinary wood. (See Guaiacum.)

LIGROIN—See Petroleum Ether.

LIMA WOOD—See Pernambuco.

LIME—See Calcium Compounds (p. 121).

LIME ACETATE, BISULPHITE, and SUPERPHOSPHATE—See Calcium Compounds and Superphosphate of Lime.

LIME WASHES—See A. D. Cowper (*C.T.J.*, 1927, **80,** 574) and Casein.

LIME WATER—See Calcium Compounds (p. 122).

LIMELIGHT—See Light, p. 533.

LIMES (OIL OF)—The essential oil of the rind of *Citrus limetta*, containing from 6 to 10 per cent. citral, pinene, dipentene, and limonene; sp. gr., 0·872 to 0·885 at 15° C.; opt. rot., +35 to +40; and ref. ind., 1·476 to 1·485 at 20° C. It is soluble in alcohol, ether, etc., and used as a flavouring material; also in perfumery, confectionery, etc.

LIME-SEED OIL—The oil obtained from the pips (seeds) of *Citrus media*, var. *acida*, as a by-product in the citrus industry, amounting in all to some 39·8 per cent.; greenish-yellow to light brown in colour, sp. gr. 0·9236 at 15°/15° C., acid v. 13·6, sap. v. 197·7, i.v. (Hübl) 109·5, and ref. ind. 1·4635 at 40° C. There are several varieties, and in general it resembles cotton-seed oil, and might be used in soap-making, but presents difficulties in refining for edible use. The meal has a high manurial value and good feeding value.

A. E. Collens gives the following values in respect of a sample of clarified oil: Sp. gr. at 27°/15·5° C., 0·9138; solidifying point, −3° C.; n^{28}_{D}, 1·4740; acid v., 11·2; sap. v., 193·5; i.v., 109·7 (Hübl); soluble in alcohol per cent., 0·18; unsap. matter per cent., 0·72. (*Analyst*, 1926, **51,** 510.)

LIME-SODA—Method of causticizing. (See R. F. Stewart, *Ind. Chem.*, 1930, vi., 194.)

LIMESTONE—See Calcium (Carbonate).

LIMONENE—**Dextro-limonene**—The oil of orange rind consists almost entirely of this terpene ($C_{10}H_{16}$), which is also a constituent of carvene, dill oil, and citron oil. It boils at 175° C.

Lævo-limonene is present to some extent in the oil of fir-cones, associated with other terpenes.

Dipentene is inactive limonene. (See Dipentene and Orange Oil.)

LIMONITE ($2Fe_2O_3,3H_2O$)—Sp. gr. 3·6 to 4·0. (See Iron.)

LIMPID—The character of clear and transparent fluids, the particles of which exhibit great mobility or rapidity of movement.

LINALOE OIL—A Mexican distilled wood-oil from *Bursera delpechiana* and *B. aloexylon* to extent of about 3 per cent.; colourless, fragrant, containing linalool and geraniol, of sp. gr. from 0·875 to 0·890, soluble in alcohol and ether, and used in perfumery.

LINALOOL (Coriandrol, Linalol) ($C_{10}H_{18}O$)—A liquid of sp. gr. 0·873 and b.p. 195° C., contained in linaloe oil, and isomeric with geraniol and nerol; occurring as linalyl acetate ($C_{10}H_{17}C_2H_3O_2$) in the cacao-bean and the oils of bergamot, lavender, coriander, neroli, and sage. It is soluble in alcohol and ether, and used in perfumery. Linalyl acetate can be made by the action of acetic acid on linalool in presence of sulphuric acid; it boils at 108° C., and is also used in perfumery. (See Kaufmann and Kjelsberg (*B.C.A.*, 1927, B, 923), and Linaloe Oil.)

LINARITE—A crystalline, mineral, basic, cuprous-lead sulphate ($PbSO_4,CuH_2O_2$) (crystal system, No. 5, and sp. gr. 5·3 to 5·45).

LINDEN OIL—See Basswood Oil.

LINEN—Cloth manufactured from the fibres of the flax stem. Linen yarn is stated to usually contain about 25 per cent. of impurities, which are more or less removed in the bleaching processes effected by means of hypochlorites after scouring with an alkaline solution. Physical tests such as those affecting strength, extension, stiffness, rigidity of linen materials depend largely upon the moisture content. (See M. Fort on "The Effect of Laundering on the Life of Linens and Cottons" (*Chem. and Ind.*, 1929, **48**, 805); W. H. Gibson on "The Linen Industry" (*Chem. and Ind.*, 1931, **50**, 262); and Linseed Oil.)

LINOLEIC ACID (**Linolic Acid**) ($C_{17}H_{31}.COOH$) occurs as a glyceride in linseed, poppy, hempseed, and other drying oils, and as a smaller constituent of some non-drying oils. When pure it is a water-white oily liquid which remains fluid at −18° C. and has a b.p. of 229° to 230° C. under 16 mm. pressure. A sample of this acid prepared from poppy-seed oil has been reported to have i.v. (Hanus) 178·6, acid v. 196·7, sp. gr. at 20°/4° C. 0·9025, and m.p. −25° to 24° C. More recently it has been described as having a m.p. of −7° to −8° and b.p. 202° C. (D. Holde and R. Gentner (*B.C.A.*, 1925, B, 600, and R. D. Haworth (*J.C.S.*, 1929, p. 1456).) (See also Linseed Oil.)

LINOLENIC ACID ($C_{18}H_{30}O_2$) occurs as a glyceride in linseed, hempseed, and some other drying oils, and is very oxidizable. It is nearly colourless, of fishy odour; sp. gr. 0·9228 at 15·5° C.; soluble in alcohol and ether, and furnishes a zinc compound $(C_{18}H_{29}O_2)_2Zn + \frac{1}{2}ZnO$, m.p. 72° to 73° C. (See Elæostearic Acids and Linseed Oil.)

LINOLEUM—Linoleums are made by coating a suitable fabric such as canvas with mixtures of raw and boiled linseed oil and impregnating or coating with mixtures of "linoleum cement," powdered cork, and the desired pigments, by hot rolling: the linoleum cement being itself a mixture of boiled linseed oil, gums or resins, cork-dust, pigment, and other filling materials. It is alleged (by W. F. Reid) that a good linoleum cannot be obtained without the presence of a certain percentage of oxide of iron. (See *C.T.J.*, 1924, **75,** 9; *Ibid.*, 1927, **80,** 489; *Ind. Chem.*, 1925, i., 377; and Oil Cloth.)

LINOXYN—See Linseed Oil.

LINSEED OIL is expressed by pressure from ground flax seed (*Linum usitatissimum*), supplies coming from Argentine, British India, the U.S.A., and Canada; the Argentine having some 3,500,000 acres under cultivation and India about 3,019,000 acres, while most of that crushed in Japan is imported from China. The world's output in 1924 was estimated at 75,171,000 centals from 18,056,000 acres.

Linseed yields by pressure alone from 18 to 20 per cent. ("cold drawn"), but when aided with heat, about 27 per cent. of oil, and by total extraction up to 38 per cent. on average; it contains about 7 to 9 per cent. water, 19 to 22 per cent. albuminoids, 19 to 23 per cent. digestible carbohydrates, 5 to 8 per cent. woody fibre, and 4 to 5 per cent. mineral matter. The oil is largely used in making paints, varnishes, printing inks, linoleum, patent-leather lacquers, rubber substitutes, and soft soaps, also for treatment of scalds and burn, while the residual cake is used for feeding cattle.

The cake contains hydrocyanic acid derived from a contained glucoside, but most of it is dissipated during the maceration of the seeds and by evaporation. On average the cake as imperfectly pressed contains 10 to 11 per cent. water, 7 to 11 per cent. oil, 30 per cent. albuminoids, 6 to 10 per cent. woody fibre, and 6 or 7 per cent. mineral matter.

The oil solidifies at −27° C., has a sp. gr. at 20° C. of 0·927 to 0·932, sap. v. 188 to 195, i.v. (Hübl-Waller) 170 to 192, and ref. ind. 1·4725 at 15° C. During drying, the ref. ind. of a film rises to 1·50 and upwards. It contains 85 to 90 per cent. liquid glycerides—namely, about 5 per cent. oleic, about 80 per cent. linoleic and linolenic, the rest being glycerides of solid fatty acids, chiefly palmitic. It is typical of the class of "drying oils" so called, from their readiness to absorb oxygen upon exposure to the air, being changed thereby into a transparent, sticky mass. Linseed oil by absorption of oxygen forms the substance known as linoxyn (a complex mixture of oxidized glycerides possibly represented by the formula $C_{57}H_{96}O_{20}$), which is insoluble in ether, and reported to be capable of absorbing 15 per cent. of its weight of water.

When first expressed, the oil is pale yellow and not disagreeable in

LINSEED OIL (*Continued*)—

smell, but unless refined by treatment with a small percentage of either sulphuric acid or alkali, it quickly turns rancid, dark, and repulsive in odour. It is soluble in alcohol, chloroform, carbon disulphide, benzol, and turpentine. Heating alone, under pressure, at a constant temperature greatly increases its viscosity and the iodine value decreases, while polymerized linseed oil, resulting from the action of heat, is stated to have a sap. v. of 206. A brighter, clearer "stand" oil can be more economically produced by submerged combustion of linseed oil, using the "Hammond" burner directly submerged in oil. Upon boiling (which begins quietly at about 260° C.) until it loses one-eighth of its weight, it thickens, becomes viscid, and dries quickly upon exposure to air. The mucilage contained in raw linseed oil "breaks down" when the oil is heated to about 250° to 260° C., and after this has occurred, it is possible to clarify and dehydrate the oil by means of super-centrifugal force, thus producing a product practically equal to boiled oil which has been tanked for twelve months. The oxidation of linseed and rape-seed oils by a current of air is facilitated by the use of a little manganese dioxide or other drier, and this process enriches them with hydroxy acids, tri-glycerides deepening their colour, and giving "body" and drying properties to the product. The setting or drying of linseed oil is accelerated by the presence of such gels as size and glue, and is attributed to a wetting process induced by their presence. The bleaching of linseed oil by action of sunlight in glass-covered pots for a period of from three to six weeks is said to give a superior product, but it requires to be subsequently washed to free it from traces of acid, etc. Saponified with alkalies, linseed oil gives soft soap of a thin character. Both the ground linseed and the residual oil cake are used in making poultices.

References: Refining processes (*C.T.J.*, 1925, **76,** 610); Eibner and Reid (*J.C.S. Abs.*, December, 1925, I., 1377); G. W. Ellis on "Chemistry of Drying Oils" (*J.S.C.I.*, 1925, **44,** 401 T, 463 T, 469 T, 486 T; and 1926, **45,** 193 T); "Oxidation of Linseed Oil," by R. S. Morrell (*Ind. Chem.*, 1925, i., 68); "Rate of Oxidation," by Rogers and Taylor (*B.C.A.*, 1926, B, 986); B.E.S.A. specifications for raw linseed oil used for paint and test for drying time (*C.T.J.*, 1926, **79,** 9), and that of the boiled oil (*Ibid.*, 364); notes on accelerators and inhibitors of drying linseed oil (*Ind. Chem.*, 1927, iii., 183); "Drying of Fatty Oils," by Morrell and Marks (*B.C.A.*, 1929, B, 860); "Boiled Linseed Oil," by J. S. Remington (*Ind. Chem.*, 1929, v., 403); F. Fritz on "Removal of Mucilage from Linseed Oil" (*B.C.A.*, 1930, B, 620); Long and Chataway on "Rate of Oxidation at 160° C." (*Ind. Eng. Chem.*, 1931, **23,** 53; *cf. B.C.A.*, 1930, p. 825); Bauer and Freiburg on "Composition of Stored Linseed Oils" (*B.C.A.*, 1931, **50,** 551); "Composition of Linseed Oil," by N. E. Cocchinaras (*Analyst*, 1932, **57,** 233); also Paints and Varnishes.

LINTNER VALUE—Diastatic value or measure of the hydrolytic change of starch to maltose under stated conditions. (See Ministry of Agricul-

LINTNER VALUE (*Continued*)—

ture and Fisheries, Statutory Rules and Orders, 1929, No. 1115; H.M. Stationery Office.)

LIPASE—See Enzymes.

LIPINS (LIPOIDS)—Terms variously and loosely applied to a group of different substances, including many contained in protoplasm, fats, and esters—*e.g.*, glycerides, lecithins, phosphatides, sterols, etc.

LIQUATION—The stage reached, when heating an ore or other metallic mixture containing ingredients differing sensibly in fusibility, at which the most fusible constituent melts and flows away from the mass. The term has a somewhat special meaning in respect of alloys, which, when melted, sometimes separate more or less in layers of their several components.

LIQUIDAMBER (Storax)—See Balsams.

LIQUID COAL—See Berginization, Coal (p. 212), Fuel (Liquid), and Colloidal Fuel.

LIQUID FUEL—See *C.T.J.*, 1927, **81,** 205; and W. R. Ormandy (*C.T.J.*, 1928, **83,** 569); Brown Coals, Fuel (Liquid), Motor Spirit, Petroleum, Synthol.

LIQUID SPREADING—See Capillary Attraction.

LIQUOR AMMONIÆ—See Ammonia (under Nitrogen).

LIQUORICE JUICE, as extracted from the roots of the *Glycyrrhiza glabra* and *G. echinata* (N.O. Leguminosæ), contains a sweet, amorphous substance, soluble in alcohol and hot water, named *glycyrrhizin* ($C_{24}H_{36}O_2$), which yields glucose when boiled with dilute sulphuric acid. The plant occurs naturally in Southern Russia, Asia Minor, and Southern Asia, and is cultivated to a considerable extent in New Jersey (U.S.A.), Spain, and Italy, more being extracted in the U.S.A. than in any other country. Glycyrrhizin when pure is said to be fifty times as sweet as sucrose, and so far has been found only in the liquorice plant. (See Houseman and Lacey (*Ind. Eng. Chem.*, October, 1929.) According to A. Giammona (*B.C.A.*, 1929, A, 856), fresh liquorice juice contains 1·38 per cent. dextrose and 3·183 per cent. sucrose, and the same root, air-dried and after three months, 2·373 per cent. and 5·4 per cent. respectively of these sugars. The manufacture of liquorice paste, which normally contains from 8 to 12 per cent. of reducing sugars, is an important Sicilian industry. (See Houseman and Lacey (*B.C.A.*, 1929, B, 1031); Houseman and Swift (*Analyst*, 1930, **55,** 51); and A. Bonis on the constitution of commercial liquorice extracts (*B.C.A.*, 1930, B, 217).)

Spanish liquorice is used as a demulcent remedy for coughs, also by brewers, and in making sweetmeats and liquorice powder.

LITERATURE (Chemical)—See Chemical Literature.

LITHARGE (Lead Monoxide)—See Lead Compounds.

LITHIUM (Li) **and its Compounds**—Atomic weight, 6·94; sp. gr., 0·534; m.p. 180° to 186° C.; and b.p. 1609 ± 5° (Hartmann and Schneider, *B.C.A.*, 1929, A, 754). Lithium is a somewhat rare element found in

LITHIUM (*Continued*)—
small quantities widely distributed in nature, in association with certain minerals including *petalite, spodumene,* and *lepidolite* (*lithium mica*), deposits of which occur in Manitoba and West Ontario (Canada), the U.S.A., Sweden, France, Spain, Saxony, Bohemia, etc., all of which are, in the main, silicates of aluminium. Large deposits of lithium ore occur also in Namaqualand and the Karabib district of S.W. Africa. It also occurs in the forms of *amblygonite* ($LiAlFPO_4$) (a fluophosphate found in California, South Dakota, Saxony, and Bohemia, etc.); *montebrasite* (both with an average lithium content of about 9 per cent.), and in several mineral waters which are extensively used for medicinal purposes. Lepidolite is employed in the making of certain varieties of glass owing to its high fluorine content.

Lithium is said to have two isotopes, and in the metallic form is the lightest known solid substance. It is obtained from the fused chloride by electrolysis, and is of soft character, having a silver-like appearance, but quickly tarnishes when exposed to the air, so that it has to be kept in naphtha or kerosene. Like sodium, it decomposes water at the ordinary temperature, lithium hydroxide being formed and passing into solution, whilst hydrogen gas is generated. Some few hundredths of 1 per cent. incorporated in aluminium imparts to that metal a great degree of hardness.

When volatized in hydrogen gas, lithium hydride is formed, and this product, when subjected to electrolysis, gives off hydrogen at the anode —the first known instance of that element functioning as a negatively charged ion. It also combines with nitrogen of the air at ordinary temperatures, forming the nitride Li_3N.

Lithium oxide (lithia) (Li_2O) exhibits alkaline properties, and in common with the carbonate is used medicinally as an antidote to gouty complaints by removal of uric acid.

The volatile lithium salts give a crimson tinge to flame, and among the best-known lithium compounds are the hydroxide ($LiHO$), carbonate (Li_2CO_3) (only slightly soluble in water), chloride ($LiCl$), and phosphate (Li_3PO_4).

The hydroxide is used in the construction of certain electrical storage batteries, while the chloride, bromide, citrate, and iodide are all soluble in water and used in medicine. The carbonate, citrate, and iodide are also used in compounding mineral waters, whilst the fluophosphate and the fluoride are used in ceramics and enamels, as also lepidolite.

An account of "Industrial Lithium" will be found in the *C.T.J.*, 1929, **85**, 621; and one by Pearson and Robinson on "Lithium Polysulphides" (*J.C.S.*, 1931, p. 413).

LITHOPONE—See Paints.

LITMUS—A violet-blue colouring matter used as an indicator, prepared from the lichens *Lecanora tartarea* and *Rocella tinctoria* by treatment, with ammonia and potash, and then fermenting, after which alum, potash, and lime are added, and when the maximum colour is attained, sand and chalk are incorporated to give solidity to the mass preparatory

LITMUS (*Continued*)—

to drying. Litmus paper is absorbent filter or blotting paper stained by soaking in a solution of litmus and subsequent drying. Acid solutions turn this blue to red, and alkaline solutions restore the blue colour, so it is commonly used to determine the alkaline or acid nature of liquids. Litmus paper can be prepared of a neutral tint equally amenable to both reactions. Litmus solution may be used for the same purposes as litmus paper. (See Volumetric Analyses.)

LITRE—See Weights and Measures.

LIVER OF SULPHUR—An old name still used commercially in respect of a mixture of potassium sulphides as prepared by heating sulphur and potassium carbonate in a closed vessel; used as an insecticide and fungicide.

"LIVEROID"—A proprietary juice prepared from ox liver and advocated for use in cases of pernicious anæmia.

LIXIVIATION—The extraction by solution of soluble substances from materials containing them, such as *black ash*—that is, crude sodium carbonate, as made by the old Leblanc process. (See Leaching and Sodium (Carbonate).)

LOADSTONE (Lodestone)—See Iron (p. 491) and Electricity (p. 293).

LOAM—Clay more or less mixed with sand or marl.

LOBELANINE (Lobeline)—An alkaloid isolated from the seeds of the *Lobelia* plant (*Lobelia inflata*), stated to have the composition $C_{22}H_{25}O_2N$; used in medicine as an antispasmodic in respiratory troubles. (See abstracts of various papers by H. Wieland (with others) dealing with the alkaloidal contents of *Lobelia* (*B.C.A.*, 1929, A, 1085-1086, and 1932, A, 68) and by F. R. Curtis and S. Wright (*Lancet*, 1926, **211**, 1255).)

LOCUST-KERNEL (GUM AND OIL)—Prepared from the endosperm of the locust or carob bean (*Ceratonia siliqua*). See A. L. Williams (*Analyst*, 1928, **53**, 411); *C.T.J.*, 1929, **85**, 402; and R. Hart (*B.C.A.*, 1930, A, 1145).)

LODE—A vein or fissure in rocks filled with metalliferous deposit.

LODGE-COTTRELL PROCESS—See Cottrell Precipitating Plant.

LOGWOOD EXTRACT (Hematine) is made from the heart-wood of a tree (*Hæmatoxylum campechianum*, N.O. Leguminosæ) which grows in Mexico, Central America, and the West Indies, and is one of the leading articles exported from Haiti. It yields its fine red colour both to water and alcohol—the latter more readily—but the colour left to itself turns yellowish and subsequently black. It is turned yellow by acids, while alkalies deepen it and give it a more purple hue. A blue colour can also be obtained from it by mixing with verdigris.

One ton of "crystals" is yielded by about from 8 to 9 tons of the wood, and a slightly smaller amount of "liquid extract." The yellowish-brown substance is known as hæmatoxylin ($C_{16}H_{14}O_6$), which crystallizes with one or three molecules of water. The logwood of British

LOGWOOD EXTRACT (*Continued*)—

Honduras is claimed to be superior to Jamaica logwood, and Campeachy logwood, which comes from Yucatan, is said to be the best.

It is used in ink-making, but chiefly for wool-dyeing and black colours (to which it imparts great lustre), and in past time it was extensively used in compounding various colours on cloth and other stuffs.

LOW-TEMPERATURE CARBONIZATION—See Coal.

LOW-TEMPERATURE DISTILLATION—See Coal.

LUBRICANTS AND LUBRICATION—Lubricants are used to decrease the friction between opposed solid faces, which arises, as is supposed by some, from true cohesion (mutual attraction). By others, it is said that in a good lubricant an enormous army of molecules is held together by electrical forces without there being any chemical change. The solid varieties include natural and artificial graphite, talc, mica, metallic soaps, and other substances, such as "flowers of sulphur" and white-lead, which are used for curing hot bearings, but of course they vary according to the application to be made of them.

The natural graphite is usually of the so-called flake variety, and varies in sizes of particles from $\frac{1}{10}$ in. and less than $\frac{1}{200}$ in., whilst the artificially produced kind is amorphous, and ground even finer than the natural product. A preparation of the latter is sold under the trade names of "Aquadag" (which when air-dried contains about 62 per cent. carbon), "Hydrosol" (when in admixture with water), and as "Oildag," "Oleosol," and "Kollag" when in admixture with oil.

Generally speaking, solid lubricants are applied dry in cases where for special reasons it is inadvisable or not possible to use liquid or semi-solid lubricants, otherwise they are usually employed in admixture with oil or as ingredients in greases. (See H. S. Garlick on "Lubricating Greases" (*C.T.J.*, 1931, **88**, 581, and some following numbers).)

"Aquadag" used as a cylinder lubricant has been found advantageous where solid friction occurs, as in worm-gear, although equally good results have been obtained by the use of natural flake graphite; and it has been concluded that the highest lubricating value of graphite depends upon its chemical purity.

It has been represented that there are two distinct conditions concerning lubrication—viz., one in which the solid surfaces are separated by a film of liquid oil, the friction depending upon the viscosity of the lubricant; and another in which no such oil-film can form, so that the surfaces are in closer contact, and the efficiency of the lubricant then depends upon the "oiliness" and not upon the viscosity of the agent.

A method of determining the lubricating power of oils is by means of a machine which indicates the increase of temperature in a bearing rotated at a constant number of revolutions per minute.

The "Karns-Maag" method of testing lubricating grease by measuring the depth of impression made by a standard ball from a given height is described in one of the references given below.

The lubricating value of oil depends upon something not yet properly understood; it is not merely viscosity. What, however, is required in a

LUBRICANTS AND LUBRICATION *(Continued)*—

liquid lubricant is that it shall penetrate into the narrow spaces between journal and bearing, thus "wetting" or spreading over the surfaces which are in motion together.

The function of a lubricant is to keep metal surfaces separate with a minimum expenditure of energy. Vegetable and animal oils possess greater value than mineral oils obtained from crude petroleum and coal tar, which are also used as lubricants in common with the so-called rosin oil obtained by the destructive distillation of resin. They are generally graded in accordance with their specific gravities and viscosities. (See Viscosity.)

The so-called "germ process" of lubrication employs one or more fatty acids with mineral oil as the instrument of lubrication, 1 or 2 per cent. being incorporated according to chemical circumstances. This is said to reduce the coefficient of friction from 0·0084 to 0·0052—that is, some 25 per cent. on a friction-testing machine.

Mineral lubricating oils contain only a small percentage of paraffin hydrocarbons of the C_nH_{2n+2} series, and consist chiefly of those which range from C_nH_{2n} to C_nH_{2n-8}. In oil refining, care should be taken not to destroy the more stable unsaturated hydrocarbons to which the viscosity of the oil is largely due, it having been shown that an increase in viscosity occurs concurrently with a decrease in the hydrogen content. The saturated compounds are principally naphthenic, and these, as also the solid resinous components containing oxygen, are probably causes of "gumming," and their removal, together with the more oxidizable unsaturated hydrocarbons, reduces the "gumming" tendency. (See Antony Seton, *Chem. and Ind.*, 1929, **48,** 82.)

Langmuir regards "polarity or unsaturated chemical affinity as an essential factor for the production and maintenance of a boundary film." Experiments with naphthene hydrocarbons appear to show that there is a linear relationship between lubrication and molecular weight; the greater the latter, the more efficient is the lubricant (W. F. Seyer and S. R. MacDougall). (See *B.C.A.*, 1925, B, 389.)

The de-waxing of petroleum lubricating stocks is done by refrigerating the oil so as to throw the wax out of solution, naphtha being employed to dilute the stock if desirable and centrifugal force to complete the separation.

The viscosity varies with the temperature; the hotter the oil the lower is its viscosity, and conversely the colder it is, the thicker it becomes. In a paper on "Viscosity-Temperature Relations," by W. L. Baillie, a table is given showing the kinematic viscosities of oils and the "Redwood" efflux times (*J. Inst. Petroleum Tech.*, 1930, **16,** 643).

Oils exhibit a rapid increase in viscosity with pressure, this increase being much greater for the mineral than for animal and vegetable oils.

The essential tests for valuation of lubricants are sp. gr., viscosity, cold test, flash-point, coke test, and appearance.

An old lubricant for stopcocks, known as Travers', consisted of a mixture of rubber, "vaseline," and paraffin wax, and an improved one has been described by E. G. R. Ardagh and A. L. Davison, made from

LUBRICANTS AND LUBRICATION (*Continued*)—
pale crepe rubber 7·5 per cent., white petroleum-"vaseline" 77·5 per cent., and paraffin wax of m.p. 128° to 130° F. 15 per cent. The "vaseline" and wax are first melted together, and the rubber cut into small bits gradually added, keeping the mixture in motion at 130° C. for some six hours, after which it is allowed to set into an unctuous mass.

An electro-plating lubricant consists of mineral oil with some 50 per cent. zinc oxide with or without added fats (*Ind. Chem.*, 1929, v., 412).

References: Description of the carbon residue test, by W. M. Seaber (*Ind. Chem.*, 1925, i., 79, and ii., 193); "General Properties of Lubricating Oils," etc., by Dunstan and Clarke (*Chem. and Ind.*, 1926, **45**, 690; *C.T.J.*, 1926, **78**, 375; and 1927, **81**, 556); Marshall and Barton (*J.S.C.I.*, 1927, **46**, 130 T); report on discussion concerning lubricating oils (*C.T.J.*, 1926, **78**, 410, and 1927, **80**, 339); Methods of Recovery of Lubricating Oil," by A. J. Broughall (*Chem. and Ind.*, 1927, **46**, 1096 and 1112); A. Seton (*Chem. and Ind.*, 1928, **47**, 1142, and 1929, **48**, 54); "Development of Modern Methods of Testing Lubricating Oils," by J. C. Jennings (*Chem. and Ind.*, 1929, **48**, 1104 and 1128); "Technique of Practical Lubrication," by A. Mosser (*B.C.A.*, 1930, B, 85); "Analysis of Commercial Lubricating Oils by Physical Methods" (Lubrication Research Technical Paper No. 1, H.M. Stationery Office, 1930); H. S. Garlick on "Lubricating Greases" (*Ind. Chem.*, 1931, vii., 249); H. S. Garlick, *C.T.J.*, 1931, **88**, 581, and **89**, 107; H. N. Bassett on "Carbonization of Lubricating Oils" (*Chem. and Ind.*, 1931, **50**, 527); W. Kay on "Mineral Oils and Lubrication" (*Chem. and Ind.*, 1931, **50**, 691); Lubricants (Rubber Greases) for High Vacuum Conditions (*C.T.J.*, 1931, **89**, 472); *Lubrication and Lubricants* (5th edit.), by L. Archbutt and R. M. Decley (Griffin and Co., Ltd.); *The Principles and Practice of Lubrication*, by Nash and Bowen (Chapman and Hall, Ltd.); *Theory of Film Lubrication*, by R. O. Boswall (Longmans and Co.); Cutting Fluids, Interfacial Tension, and Soaps (Metallic).

LUCERNE (*Medicago sativa*)—A leguminous plant, useful as a green food for cattle, largely grown in North and South America, and known in Spanish lands as *alfalfa*. When carefully cured in the dark, alfalfa is reported to be rich in vitamin A, and the juice of the plant is stated to contain the base adenine (6-amino-purine). (See Alfalfa and Esparto Grass.)

LUMBANG OIL—See Candle-nut Oil.

LUMINOSITY—See Flame, Light, Phosphorescence, Radium, and Zinc (Sulphide).

LUMINOUS PAINT—See Calcium (Sulphide and Tungstate), Paints, and Radium.

LUNAR CAUSTIC—Fused silver nitrate. (See Nitrate.)

LUPIN ALKALOIDS—Contained in various species of lupins (*L. luteus, L. niger, L. albus, L. angustifolius,* and *L. polyphyllus*), including lupinine ($C_{10}H_{19}ON$), sparteine ($C_{15}H_{26}N_2$), and another body named

LUPIN ALKALOIDS (*Continued*)—lupinane, to which the formula $C_{10}H_{19}N$ (b.p. 82° to 83° C.) has been assigned.

Lupinine is described as a white, crystalline, poisonous body, of m.p. 68° to 69° C., soluble in alcohol and ether, but decomposed by water. (See Clemo and Leitch (*J.C.S.*, 1928, p. 1811); Karrer (with others) (*B.C.A.*, 1929, A, 200); Clemo and Raper (*J.C.S.*, 1929, p. 1927); Clemo, Raper, and Tenniswood (*Ibid.*, 1931, p. 429); Clemo and Ramage (*Ibid.*, 1931, p. 437); Clemo, Ormston, and Ramage (*Ibid.*, 1931, p. 3190); Winterfeld and Holschneider (*B.C.A.*, 1931, A, 370-371); and Schöpf, Schmidt, and Braun (*B.C.A.*, 1931, A, 635).)

LUPULIN—See Hop.

LUTECIUM (Lu)—Atomic weight, 175. One of the extremely rare, recently discovered elements of the yttrium group.

LUTES—Cements of refractory or other materials used to pack, seal, or repair the joints of manufacturing plant, varying in nature according to the chemicals concerned. Among these are litharge-glycerine cements, which resist the action of strong mineral acids and ammonia in a high degree, but are not stable against caustic alkalies and strong acetic acid. One good mixture recommended is 50 grammes litharge and 60 c.c. of a mixture of 5 parts glycerine and 2 parts water; this hardens in ten minutes, and after three hours becomes very hard. Water is said to be a product of the reaction which has been represented as $3PbO + 2C_3H_5(OH)_3 = Pb_3(C_3H_5O_3)_2 + 3H_2O$. (See H. N. Neville (*B.C.A.*, 1926, A, 1092), and H. Stager (*B.C.A.*, 1929, B, 520).

Hart's Indiarubber Cement is made from 12 parts raw linseed oil heated together with 12 parts masticated rubber worked up into a stiff paste with "paper stock" asbestos. It is a good cement for caulking glass pipes, such as those used for conveying hydrochloric acid gas. Other materials employed include clay, pitch, tar, putty, linseed meal, bitumen, Portland cement, asbestos mixtures, etc. A cement for fixing iron in stonework is referred to under Ammonium Chloride (see p. 615). An acid-proof composition is made by melting together 30 to 40 parts sulphur with 60 to 70 parts of sand, and raising the temperature to 150° C., in which pasty state it is used as a plaster. (See Cements, "Prodorite," Magnesia, and "Ruskitt.")

"LUXMASSE"—See Berginization.

LYCOPODIUM—The fatty acids of lycopodium oil, from *L. clavatum,* comprise 72 per cent. of unsaturated and 28 per cent. of saturated character (Bauer and Piners, *B.C.A.*, 1930, B, 247).

"LYDDITE"—See Explosives (Picric Acid).

LYE (**Ley**)—A solution of alkali such as used in soap-making.

LYMPH—Transuded serum of blood which has been reabsorbed from the tissues and carried back to the circulation by the lymphatics. It is alkaline, contains about 5 per cent. solid constituents made up of

LYMPH (*Continued*)—

plasma and white corpuscles, and is really diluted blood-serum, from which the tissues have taken up what they require for nourishment.

"LYSOL"—The name now used in respect of a number of fluid antiseptics prepared from castor or linseed-oil soap, and containing 50 per cent. cresol in a form miscible with water, making clear solutions. (See A. J. Jones, *C. and D.*, July 25, 1931.)

MACASSAR OIL is obtained from the seeds of *Schleichera trijuga* (India, Malay, and East Indian Archipelago). The fat from the seeds extracted by ether or carbon tetrachloride is yellowish-white, of pleasant odour, has a sp. gr. at 99° / 15° C. of 0·86, m.p. 21° C., sap. v. 214·4 to 229·1, and i.v. 52·4 to 55. It is used for burning purposes, in soap-making, as an edible oil, and in medicine. (See Dhingra, Hilditch, and Vickery (*J.S.C.I.*, 1929, **48,** 281 T).)

MACBETH LAMP—See Light, p. 535.

MACE—The *arillus* or envelope of the shell of the fruit of the nutmeg (*Myristica moschata*), cultivated in the Molucca Islands and the tropics (East Indies, India, etc.), containing two varieties of essential oil. The seeds also yield a volatile essential oil, which forms a soapy mass with alkalies, but these oils are not to be confused with the fixed oil or butter called myristin, which is *expressed* from the seeds containing trimyrstin, m.p. 56·2° C. Mace is used as a condiment in cooking, having a more agreeable odour than nutmeg, also in making sauces and pickles. (See Mace Oil and Nutmeg Oils.)

MACE OIL (Ex Arillus of Nutmeg)—A colourless or slightly yellow oil of aromatic odour, containing camphene, terpineol, dipentene, etc., obtained from the fruit of *Myristica fragans* to the extent of from 5 to 12 per cent.; sp. gr. 0·89 to 0·93 at 15° C., opt. rot. +10 to +20, and ref. ind. 1·476 to 1·480 at 20° C. It is soluble in alcohol, ether, etc., and is used in perfumery, flavouring, and for incorporation in purgative pills. (See Nutmeg Oil.)

MACROCHEMISTRY—Methods of chemical examination of quantities *en masse*, as contrasted with atomic or molecular amounts and as distinguished from microchemistry. (See Microchemistry.)

"MACROME" (STEEL) PROCESS—For lengthening the life of finished steel goods. (See *The Times* Trade and Engineering Supplement, November 28, 1931.)

MADDER (Turkey Red)—The pulverized root of various species of Rubia, the most important being *Rubia tinctorium* (N.O. Stellatæ), an herbaceous perennial cultivated in Alsatia, the Levant, France, and Holland. It grows best in warm climates and contains the glucoside rubian (rubiadin) which yields by fermentation the beautiful red dye known as alizarin. It also contains purpurin. (See Alizarin and Purpurin.)

MAFURRA SEED OIL (Mafoura)—From Portuguese East Africa; is yielded to the extent of 33 to 60 per cent., and reported to have an i.v. of 46 to 47·5. (See Mafurra Tallow.)

MAFURRA (MAFOURA) TALLOW—A product of the nuts of *Trichilia*

MAFURRA (MAFOURA) TALLOW (*Continued*)—

emetica from Portuguese East Africa; being a solid fat obtained from the husk and kernel, and different from the oil obtained from the aril; sap. v. 202·5, i.v. 66, m.p. from 35° to 45° C.

MAGADI SODA—A published analysis of Magadi soda crusts is as follows: 33·84 per cent. $NaHCO_3$, 45·44 per cent. Na_2CO_3, 2·30 per cent. NaCl, 1·66 per cent. insoluble matter, and 16·73 per cent. H_2O. (See Sodium.)

MAGENTA or FUCHSINE—A crystalline aniline dye, being a compound of rosaniline with an acid, prepared originally by the oxidation of aniline with stannic chloride and among other methods by heating a mixture of nitro-benzene, aniline, and toluidine with iron filings and hydrochloric acid. It dyes silk and wool direct. (See Rosanilines and Triphenylmethane.)

MAGISTRAL—A crude mixture of cupric and ferric sulphates and oxides, prepared by roasting pyrites, and used in the Mexican amalgamation silver extraction process. (See Silver.)

MAGMA—A paste of finely divided material.

MAGNESIA—See Magnesium Compounds.

MAGNESITE—See Magnesium.

MAGNESIUM (Mg) **and its Compounds**—Atomic weight, 24·3; sp. gr., 1·75; m.p., 651° C.; b.p., 1380 ± 5° C. (Hartmann and Schneider, *B.C.A.*, 1929, A, 754); credited with three isotopes. Magnesium is not found uncombined in nature, but exists abundantly in combination with calcium as a double carbonate in the form of the mineral *dolomite*, containing variable proportions of the two substances.

Magnesite, or *Greekstone,* is essentially magnesium carbonate ($MgCO_3$), crystal system, No. 3, and sp. gr. 3·0, and in some forms is nearly pure, large deposits occurring in Canada, Venezuela, Greece, Austria, Hungary, India, Manchuria, Russia, and other countries, and extensively used for making refractory bricks. These are made by grinding the magnesite as fine as possible, and made into bricks before kilning slowly to 600° for twenty-four hours, after which the temperature is raised to 1,650° C. for seventy-two hours. The calcined material is then ground with sufficient water to make a pasty mass until 95 per cent. passes through a sieve of thirty meshes to the inch, after which the material is again moulded into bricks, dried for some seven days, and then kiln-fired at 1,650° C. for seven days (G. H. Read). Articles of fused magnesite such as crucibles are now also produced, the sp. gr. of the fused material, which is of a milky amber colour, being 3·5 to 3·62. An article on Canadian magnesite by F. E. Lathe is reproduced in the *C.T.J.*, 1930, **86**, 156. The output in Greece in 1924 was 58,200 metric tons.

Brucite is a native form of magnesium hydroxide ($Mg(HO)_2$) found in serpentine rocks in Shetland and Texas. *Periclase* is a native oxide of magnesium (MgO), and *spinelle* is a natural crystalline magnesium aluminate. *Kieserite* is magnesium sulphate ($MgSO_4,H_2O$), and *carnallite* (one of the Stassfurt salts) is a double chloride of magnesium and

MAGNESIUM COMPOUNDS (*Continued*)—

potassium ($MgCl_2.KCl.6H_2O$), from which substance in a fused state, as also from *magnesite*, magnesium in a metallic form is chiefly produced by electrolysis. (An account of the metal manufacture is given by W. G. Harvey (*C.T.J.*, 1925, **76**, 603).)

It is stated that the crude metal can be satisfactorily purified by distillation at 650° to 800° C. under pressure of a few mm. of mercury and excellent commercial results by subliming the metal at 600° under 0·5 to 1·5 mm. (H. E. Barken, *B.C.A.*, 1929, B, 685).

It has been seriously proposed to extract the metal from the magnesium salts contained in sea-water in Norway, where water-power is readily and economically available.

Magnesium is a silver-white metal which tarnishes slightly upon exposure to the air; is used in pyrotechnics and making some alloys, and readily takes fire when heated in the air, combining with the oxygen thereof, forming magnesium oxide (MgO). This burning is attended with a brilliant white light often used for photographic purposes. Acted upon by dilute acids, hydrogen is evolved and the corresponding salts of magnesium are produced in solution. The metal is 35 per cent. lighter than aluminium, and has a tensile strength about twice of that metal; an alloy of the two metals with 80 per cent. magnesium has been found to be possessed of excellent qualities for use in the construction of motors for aeroplanes, automobiles, and electric tramcars.

The addition of as little as 0·5 per cent. magnesium to many alloys, such as those of aluminium and copper, and copper and zinc, results in a remarkable age-hardening after quenching, said to be analogous to the hardening and tempering of steel. (See W. R. D. Jones (*B.C.A.*, 1930, B, 424) on its tensile strength, Brinell hardness, and other qualifications; "The Economic Prospects of Magnesium as an Alloying Element" (*C.T.J.*, 1926, **79**, 530); and "The Corrosion and Protection of Magnesium and Magnesium-base Alloys," by L. Whitby (*Ind. Chem.*, 1931, vii., 203); Alloys and Magnolia.)

The **Oxide** (MgO) occurs in nature in the mineral *periclase*, and is produced in the form of *calcined magnesia* when magnesium carbonate is subjected to a sustained heat. Its production from dolomite is the subject of an article by L. Cambi (*B.C.A.*, 1931, **50**, B, 18). The product when pure is white and light, and it is used as a cement owing to its double capacity of slowly absorbing carbon dioxide and moisture. When prepared by heating the carbonate to 800° C. and mixed with a strong solution of magnesium chloride, the mixture sets to a hard compact cement. It is also used for heat insulating, and, owing to its refractory character (m.p. about 2,800° C.), is of peculiar value for the manufacture of crucibles and cupels for metallurgical purposes. (See Sorel Cement and Xylolith.)

Magnesium Hydroxide ($Mg(OH)_2$) is obtained as a white precipitate upon addition to a soluble magnesium salt of a solution of sodium hydroxide, and in the dry state is used in sugar-refining.

MAGNESIUM COMPOUNDS (*Continued*)—

The **Peroxide** (MgO_2), prepared by reaction between sodium or barium peroxide and strong solution of magnesium sulphate, is a white powder insoluble in water, used as a bleaching agent for wool and silk fabrics.

Magnesium Oxychloride—See Sorel Cement.

Magnesium Sulphate (**Epsomite,** or **Epsom Salts**) ($MgSO_47H_2O$) (crystal system, No. 4), occurs in quantity in the Stassfurt salt deposits (*kieserite*), and there are deposits in a number of places in Wyoming, Washington, Utah, and California in the U.S.A.; also in Canada and elsewhere. It mainly occurs as white, granular, fibrous, or earthy masses or in crusts, and is a common constituent of mineral waters, such as those of Epsom, in Surrey. It is readily obtained in solution from *kieserite* or by the action of sulphuric acid upon *dolomite* and separation of the insoluble calcium sulphate thus formed, and is a colourless, crystalline salt, soluble in water, used as a medicine; also in fireproofing, warp-sizing cotton goods, and as a fertilizer. Its manufacture by the "Dow" method consists in the formation of the sulphite by absorption of sulphur dioxide in magnesium hydrate and oxidation of the sulphite by blowing with air under specified conditions. (See *C.T.J.*, 1930, **86**, 108.)

Magnesia Alba, of the pharmacists, is a varying mixture of magnesium carbonate and hydroxide, made by precipitating a boiling solution of magnesium sulphate with a hot solution of sodium carbonate; it is used in fireproofing and as a face-powder, etc.

Magnesium Chloride is a deliquescent body very soluble in water, which can be obtained in crystalline form ($MgCl_26H_2O$), as also in the anhydrous state ($MgCl_2$). It loses two molecules of water at 100° C., and is used for dressing cotton fabrics, fireproofing wood, etc. (See Potassium Chloride, p. 728.)

Magnesium Carbonate ($MgCO_3$)—The precipitate obtained by adding an alkaline carbonate to a solution of magnesium sulphate is not a pure $MgCO_3$, but a basic compound of somewhat varying composition according to varying conditions of precipitation. By suspension in water and saturation with carbon dioxide, the precipitate dissolves, and only upon heating to 300° C. under pressure is the normal anhydrous carbonate deposited in rhombohedral crystals. The nature of the precipitates obtained as above described has formed the subject-matter of investigation by Menzel and Brückner (*B.C.A.*, 1930, A, 435). These precipitates and the real carbonate can be used in common with natural deposits of the carbonate in admixture with asbestos for covering steam-pipes; also in fireproofing, making tooth-powders, as clarifying agents, and for preventing the formation of scale in boilers.

Magnesium Citrate ($Mg_3(C_6H_5O_7)_2.14H_2O$) is a soluble white salt used in medicine.

Magnesium Nitrate ($Mg(NO_3)_26H_2O$) is a white, crystalline salt, soluble in water, used in ceramics and pyrotechnics.

MAGNESIUM COMPOUNDS (*Continued*)—

Magnesium Fluoride (MgF_2) is a white, crystalline compound used in ceramics.

Magnesium-Ammonium Phosphate ($MgNH_4,PO_4,6H_2O$) is a white powder insoluble in water, used in medicine, and obtained by addition of magnesium sulphate solution to one of a phosphate solution in presence of ammonium chloride and ammonia.

Magnesium Silicate (Talcum) ($3MgSiO_3,5H_2O$)—A white compound, insoluble in water, prepared by interaction of a soluble silicate and a magnesium salt in solution; used in medicine.

Magnesium Perborate (MgB_4O_7), a soluble white powder used in making driers.

The perchlorate ($Mg(ClO_4)_2$) as also the oleate are similarly used.

Many magnesium salts are prepared for medicinal use.

MAGNET—See Electricity.

MAGNETIC IRON ORE (Loadstone, Magnetite) (Fe_3O_4)—Crystal system, No. 1, and sp. gr. 5·0. (See Iron and Loadstone.)

MAGNETIC ROTATION—That of a plane of polarized light exercised by a substance in a magnetic field. (See Electricity, p. 293.)

MAGNETIC SEPARATION (in Chemical Industry)—See B. I. Rolling (*Chem. and Ind.*, 1926, **45,** 344 and 352).

MAGNETISM—See Electricity, p. 293.

"MAGNOLIA"—An alloy of 80 parts lead, 15 antimony, and 5 tin; modifications are made for spindles, high-speed shafting, and dynamo bearings.

"MAGNOLIUM"—See Alloys.

MAHOGANY—Wood of the *Swietenia mahagoni,* N.O. Cedrelaceæ, of the W. Indies and S. America. The E. India mahogany comes from the Rohuna tree (*Soymida febrifuga*) and the African variety from the *Khaya Senegalensis.* The wood varies greatly in value in respect of each sort according to their several physical features, etc.

MA HUANG—See Ephedrine.

MAIZE OIL (Corn Oil)—From the germs of Indian corn or maize plant (*Zea Mays* L.), constituting a by-product in the preparation of maize starch. It is golden-yellow in colour, sp. gr. at 25° C. 0·9105, and is composed of the glycerides of oleic acid (45·4 per cent.), linoleic acid (40·9 per cent.), palmitic acid (7·7 per cent.), of stearic acid (3·5 per cent.), arachidic acid (0·4 per cent.), lignoceric acid (0·2 per cent), and 1·7 per cent. of unsaponifiable matter; i.v. (Hanus) 117·2, sap. v. 187·3, ref. ind. 1·4768 at 15° C. It solidifies at from −10° to −20° C. The unsaponifiable matter of the oil is stated to consist largely of a phytosterol identical with sitosterol, of m.p. 137·5° C. The seeds yield from 6 to 10 per cent. of the oil, which is soluble in ether, chloroform, and benzol; is edible, and used in soap-making, also as a rubber-filler, for lubricating and leather-dressing, etc. Thin lumber substitutes are now

MAIZE OIL (*Continued*)—
made in the U.S.A. from maize stalks. It is reported that a new sweetening agent, only slightly soluble in water, has been prepared from maize residues 700 times as sweet as cane sugar. Respecting the so-named vitamin A content of maize, see S. M. Hauge (*J. Biol. Chem.*, 1930, **86,** 161); Hauge and Frost (*Ibid.*, p. 167); and Vitamins. Maize is a valuable feeding-stuff and contains a protein named zein, but is deficient in the amino-acids characteristic of wheat. (See Taylor and Werntz (*J. Amer. Chem. Soc.*, 1927, **49,** 1584); R. Shimer (with others) (*B.C.A.*, 1927, A, 798); also Xylose and Zeanin.)

MALACHITE (crystal system, No. 5, and sp. gr. 3·75 to 4·0)—Native basic copper carbonate ($CuCO_3Cu(OH)_2$) found in the Ural Mountains and elsewhere; finds use for ornamental purposes, and as a mineral pigment. (See Copper, p. 236.)

MALACHITE GREEN—An organic dye. For notes on its manufacture, see *C.T.J.*, 1929, **85,** 24. (See also Dimethylaniline.)

MALAKON (**Malacon**)—A zirconium silicate from Madagascar containing small amounts of hafnium, thorium, and other rare earths, etc.

MALE FERN OIL—A nearly colourless oil, containing hexyl and octyl esters of fatty acids, obtained to extent of something under 0·5 per cent. from the oleo-resin content, by distillation of the rhizome of *Dryopteris filix-mas marginalis*, etc. Its sp. gr. is 0·85; it is soluble in alcohol and ether; used in medicine for expulsion of tape-worms, also in compounding some varieties of gin and certain other liquors.

MALEIC ACID ($CO_2H.CH : CH.CO_2H.$), a crystalline substance readily soluble in water which can be prepared from malic acid by distillation; or cheaply from benzene in the vapour phase by catalytic oxidation over vanadium pentoxide. There are a number of processes by which it can be converted into fumaric acid. It has been found that the anhydride may be obtained from the acid in good yield by its distillation in association with a neutral high-boiling solvent such as xylene or tetrachloroethane. (See F. A. Mason, *J.C.S.*, 1930, p. 700.)

MALIC ACID ($C_4H_6O_5$ or $COOH.CH_2.CH(OH).COOH$)—Occurs, together with citric acid, in unripe apples and many other fruits, including gooseberries, cherries, bilberries, strawberries, raspberries, tomatoes, mountain-ash berries, quinces, pineapples, etc.; also in the roots and flowers of many other plants. The acid obtained from natural sources and by the action of yeast on sucrose solutions is lævo-rotatory, but the synthetically obtained acid is optically inactive. It is manufactured in the U.S.A. by the catalytic oxidation of benzene to maleic acid and conversion of that product into malic acid. A concentrated syrup left to evaporate yields the acid in the form of colourless, odourless, deliquescent needles or prisms, soluble in water, which melt at 100° C. It can be obtained from both fumaric and maleic acids in the optically inactive form by heating them with dilute alkali, and by suitable chemical treatment it can be obtained also from malonic acid. Malic acid is reported to be non-toxic, and a claim has been made that it

MALIC ACID (*Continued*)—
can be used as a substitute for citric and tartaric acids in beverages and for other applications. Maple sap contains calcium malate. The malates are soluble in water. (See J. F. Snell, *J.S.C.I.*, 1925, **44**, 140 T.)

MALLEABILITY—See Metallography and Metals.

MALLEE BARK—The bark of *Eucalyptus occidentalis* of Queensland (which yields the Dumosa eucalyptus oil), containing from 30 to 50 per cent. tannin; there is a commercial extract of 22° to 24° B., containing from 30 to 36 per cent. tannin. (See Tannins.)

MALONIC ACID ($C_3H_4O_4$ or $CH_2(COOH)_2$) is said to be contained in beetroot in combination with calcium, and may be prepared by the oxidation of malic acid. It crystallizes in white plates, is soluble in water and alcohol, and melts at 132° C.

MALT—Barley or other grain the starch of which is converted into dextrine, malt-dextrine, and maltose ($C_{12}H_{22}O_{11}$) in the mash-tun by the enzyme diastase (formed during germination in the process known as malting). One ton of malt gives some 4 tons of weak extract of density 14° Balling, or 6 tons of density 10° Balling, the yield varying from 76·5 per cent. to 79·9 per cent. according to the precise conditions of the process employed. The diastatic action of malt is practically limited to the temperature range 60° to 90° C., its activity being greatest at from 70° to 80° C., and from three to four times greater than any of the commercial extracts prepared from it. A method for the determination of the diastatic power of malts and malt extracts is described by Windisch and Kolbach (*B.C.A.*, 1925, B, 644). The "Avery Saturation Tester" is an instrument for determining the moment when barley has absorbed its maximum amount of water in the steeping process preparatory to malting. For characteristics of malt extracts from barley grown in England and Wales, see Ministry of Agriculture and Fisheries, Statutory Rules and Orders, 1929, No. 1115 (H.M. Stationery Office). The diastatic activity (Lintner value) and the protein content are determined as therein described. The soluble protein content is the amount as ascertained by multiplying the nitrogen present (other than ammoniacal or nitric acid nitrogen, if any) by 6·25, and should not be less than 5 per cent. of the total weight. (See Bennett and Bateman (*Analyst*, 1930, **55**, 763).) The preparation of malt extract for bakers' use is described in *Ind. Chem.*, 1931, vii., 169.

Maltase—An enzyme capable of hydrolysing maltose to grape sugar, but not sucrose. (See Beer and Enzymes.)

Malting—The preparation of barley or other grain by germination ready for brewing. (See "Principles of the Malting Process," by A. R. Ling (*J. Inst. Brew.*, 1931, **37**, 424); Beer and Starch.)

MALTOSE (**Malt Sugar**) ($C_{12}H_{22}O_{11},H_2O$) is a hard, crystalline body of little sweetness, very similar to grape sugar, and strongly dextrorotatory. When carefully heated to 160° C. *in vacuo* it loses water, and is resolved into the anhydride maltosan ($C_{12}H_{20}O_{10}$)—a brown

MALTOSE (*Continued*)—

amorphous powder, which does not regenerate maltose when boiled with water. During cooking, a considerable proportion of the starch content of sweet potatoes is stated to be converted into maltose, which is now regarded as a break-down product of the polysaccharides. When a solution of amylose (a member of the starch group of polysaccharides) is treated with a small quantity of barley or malt diastase at *p*H 4·5, it is converted rapidly and quantitatively into maltose, the optimum temperature for the former being 45°, and the latter between 30° and 40° (Ling and Nanji). It is strongly dextro-rotatory (+137°), and like lactose, which it resembles (and with which it is perhaps stereo-isomeric), is not fermentable until hydrolysed. (See Beer and Maltase (p. 559).)

MANDARIN OIL—A yellow oil of sp. gr. about 0·85, opt. rot. +670 to +76°, and ref. ind. 1·475, expressed from the peel of the mandarin (tangerine) orange (*Citrus bigaradia sinensis*). It contains limonene, citral, etc., is soluble in alcohol and ether, and used in perfumery, medicine, and for flavouring.

MANGANATES—See Manganese Compounds.

MANGANESE (Mn) **and its Compounds**—Atomic weight, 54·95 and alleged isotope 55; sp gr., 7·4; m.p., 1,240° C. Manganese is found in nature chiefly in the form of *pyrolusite*—a black oxide of sp. gr. 4·8 to 5·0, containing from 70 to 80 per cent. of the oxide (MnO_2); chiefly imported from Spain. Among other ores may be enumerated *braunite* (a manganese ore of the composition Mn_2O_3, crystal system, No. 2, and sp. gr. about 4·7, occurring in Sweden, the U.S.A., and India); the red mineral *hausmannite* (Mn_3O_4); *manganite*, a hydrated oxide ($Mn_2O_3H_2O$), of crystal system, No. 4, and sp. gr. 4·2; *manganese spar* (*rhodonite*) (carbonate) ($MnCO_3$), and *manganese blende*, a native sulphide (MnS). Manganiferous iron ore and other deposits occur abundantly in Spain, French Morocco, the U.S.A., Georgia, Canada, India, Brazil, Russia, Cuba, at Postmasburg near Kimberley (South Africa), and Insuta (West Africa).

The South African ore is low in phosphorus and silica content, and is stated on average to contain 53·5 per cent. manganese, 5·84 per cent. silica, 4·5 per cent. iron, and 0·059 per cent. phosphorus. In 1927 some 3,000,000 tons of manganese ores were used in the production of 90,000,000 tons of steel.

Metallic manganese can be obtained by reduction of the oxide with carbon in an electrical furnace, but is commercially prepared by using powdered aluminium for reduction of the oxide in a refractory furnace, the mixture being ignited by means of a fuse. When required in a purer state, fused anhydrous manganese chloride is reduced by heating with metallic magnesium. It is of a reddish-grey colour, is attacked by dilute acids, and extensively used in the metallic state as a hardener of certain qualities of hard and tough steel made for special applications. An alloy of manganese and boron is used in making varieties of bronze, brass, and other alloys.

MANGANESE COMPOUNDS (*Continued*)—

Electro-deposited manganese is stated to have a density of 7·034 to 7·080, burns brilliantly when heated in a current of oxygen or chlorine, and forms a nitride when heated at blow-pipe temperature in a stream of nitrogen, ammonia being also produced.

Oxides of Manganese—Of these, the most important members are represented by the formulæ MnO, Mn_3O_4, Mn_2O_3, and MnO_2. The latter combines with some other oxides—including calcium combinations—forming unstable compounds, supposed to be represented by the formulæ CaO,MnO_2, $CaO2MnO_2$, and $CaO,5MnO_2$, the manganese oxide acting the part of weak acid, and some of these compounds are supposed to be constituents of the so-called Weldon mud. (See Chlorine.)

Manganese Dioxide (MnO_2) can be prepared by adding a solution of bleaching powder to a manganous solution or by roasting the monoxide in oxygen. It can also be prepared from any lower oxide by direct oxidation with oxygen, using sodium hydroxide as catalyst at from 400° to 500°. The air-dried product is MnO_2,H_2O (Kato and Matsuhashi, *B.C.A.*, 1930, A, 308).

When dried and heated to redness it decomposes, becoming reduced to a lower oxide and giving off oxygen gas, thus:

$$3MnO_2 = Mn_3O_4 + O_2.$$

It is employed in the manufacture of chlorine and as an oxidizing agent, also in the paint and varnish trades as a drier.

Manganese Hydroxide ($Mn(OH)_2$), obtained by adding sodium hydroxide solution to a manganous solution, is a nearly white gelatinous mass which becomes rapidly brown in colour by absorption of oxygen from the air, thus passing into one of the higher oxides. It finds use as a pigment and in the ceramic industries.

Manganate and Permanganate of Potassium—Potassium permanganate ($KMnO_4$) is used in nickel refining, and both it and the manganate (K_2MnO_4) as sanitary reagents, being valued on account of their oxidizing properties. There are corresponding sodium compounds, and all are used in oxidizing, tanning, and bleaching processes.

By fusing black oxide of manganese together with potassium hydroxide or carbonate, the green manganate is obtained by dissolving the product in water:

$$4KOH + 2MnO_2 + O_2 = 2K_2MnO_4 + 2H_2O;$$

whilst the crystalline red permanganate is now chiefly made by the electrolysis of the manganate solution at a temperature of about 60°, using iron electrodes.

Another method of manufacturing potassium permanganate consists in first of all making sodium permanganate by fluxing manganese ore with caustic soda (with or without the addition of sodium nitrate as an oxidant), dissolving the product after grinding in water, and treating the solution with chlorine and sulphuric acid, or alternatively with carbon dioxide, to transform the manganate into permanganate of

MANGANESE COMPOUNDS (*Continued*)—

sodium, and subsequently mixing the filtered concentrated permanganate liquor with the theoretical amount of potassium chloride, and again concentrating the mixture by heat, when the potassium permanganate crystallizes out upon cooling.

When heated to 200° C. it begins to decompose, and the decomposition is completed at 240° C., as represented by the equation:

$$10KMnO_4 = 3K_2MnO_4 + 2K_2MnO_3 + 5MnO_2 + 6O_2.$$

The salts of manganese are flesh or pink coloured.

Manganese Chloride ($MnCl_2$) is a soluble salt which can be obtained in crystalline form as $MnCl_2,4H_2O$, and is used as a drier in oil-boiling; also in dyeing and calico-printing.

Manganese Sulphate ($MnSO_4$) can be obtained in crystalline form combined with water ($MnSO_4,5H_2O$); is used in ceramics and textile dyeing, and marketed of 95 per cent. strength.

Manganous Sulphide (MnS) is a flesh-coloured, insoluble compound, obtained by adding an alkaline sulphide solution to one of a manganous salt.

Manganous Carbonate ($MnCO_3$) in precipitated form is a slightly rose-coloured, insoluble body used in the pottery trade. In native form it occurs as an ore in Wales, but as an outcrop it is transformed into hydrated black oxide.

Manganese Borate is a white powder, prepared by precipitating solutions of manganese salts with one of borax, and has, when dry, the composition $MnH_4(BO_3)_2H_2O$, losing its water of crystallization upon heating to 100° C., and at higher temperatures becoming $Mn(BO_3)_2$. It is marketed as of 85 per cent., and used as a drier for varnishes and in the oxidation of linseed oil, being superior to lead driers but inferior to manganese dioxide, having, however, the advantage of not darkening the oil so much. A process of manufacture is described by V. V. Erin (*B.C.A.*, 1929, B, 938).

Manganese Resinate ($Mn(C_{20}H_{29}O_2)_2$)—A dark, nearly black substance, prepared by boiling manganese hydroxide with rosin oil and water. It is soluble in hot linseed oil, and is used in common with manganese borate and manganese oleate as a varnish and oil drier.

A manganese drier is also prepared by heating together common resin and manganese dioxide in certain proportions.

Manganese Oleate ($Mn(C_{18}H_{33}O_2)_2$), also used as a drier, is prepared by boiling manganese chloride with sodium oleate and water, and is a dark brown substance soluble in oleic acid.

Manganese Acetate ($Mn(C_2H_3O_2)_24H_2O$)—A pale red crystalline salt, soluble in water; used as a drier, also in textile dyeing and manufacturing bistre (a brown pigment made from soot).

Manganese Silicate ($MnSiO_3$) is a red, crystalline, insoluble substance used for colouring glass and in ceramics.

MANGANESE COMPOUNDS (*Continued*)—

Manganese salts are said to serve as plant stimulants, particularly in respect of marl soils. For some further details concerning manganese compounds in industry, see "Omega" (*C.T.J.*, 1930, **86**, 611).

MANGANESE STEEL—See Iron (Ferro-Manganese), Manganese, and R. Hadfield (*Chem. and Ind.*, 1925, **44**, 1029).

MANGANITE—See Manganese.

MANGROVE—A tannin material (cutch) containing from 35 to 40 per cent. tannin, derived from the mangrove (*Rhizophora mangle*), growing in Mozambique, Parapet, Pomba Bay, parts of East and West Africa, S. America, China, and Borneo.

MANILA GUM—See Gums.

MANILLA—Hemp fibre, used for making certain qualities of cigarette and other papers, rope, hawsers, string, etc. Some recent trials of manilla rope would appear to indicate inferiority in wear to that of sisal rope. (See Hemp and Sisal.)

MANIOC (**Manihot**)—See A. E. Williams on "Manufacture of Glucose from Manihot Root" (*Ind. Chem.*, 1931, vii., 375); Cassava and Tapioca.

MANNA—The dried juice or sweet sap from incisions made in the stems of certain species of the manna ash (*Fraxinus ornus* and *F. rotundifolia*), which grow in Calabria, Sicily, and in the East. It contains from 30 to 60 per cent. of mannitol ($C_6H_{14}O_6$), which can be extracted by hot alcohol, and is used as a mild laxative and strengthening food for children. It is also stated to contain a trisaccharide named melecitose ($3C_6H_{12}O_6 - 3H_2O$) of crystalline character. (See Mannitol.)

MANNANS—See Mannose.

MANNITOL (**Mannite**) ($C_6H_{14}O_6$ or $C_6H_8(OH)_6$)—The chief constituent of manna, and found present in the leaves of *Myoporum lactum* (Forst) —a tree indigenous in New Zealand: 0·2 per cent. in the berries and 0·25 per cent. in the wood. It is a white, crystalline body, soluble in water and to some extent in alcohol, and can be produced by the action of sodium amalgam on the mixture of dextrose and lævulose that results from the action of dilute sulphuric acid upon cane sugar when boiled together. It is not very sweet, melts at about 160° C., and by the action of dilute nitric acid is converted into mannitic acid ($C_6H_{12}O_7$ or $C_6H_6O(OH)_6$). Chemically, it is regarded as a polyhydric alcohol derived from mannose, the last-named substance being stereo-isomeric with one of the glucoses comprehended in the monosaccharoses. (See Carbohydrates.) It can be made to replace glycerol in fat (see Olive Oil); can be distilled without appreciable decomposition; does not ferment except under unusual conditions, and has been synthesized. (See E. Pace, *B.C.A.*, 1927, A, 359; and Manna.)

MANNOSE—A sugar occurring naturally in the form of polysaccharide-like condensation products termed mannans, which yield the simple hexose upon hydrolysis. Vegetable ivory (the kernels of the nuts of *Phytelephas macrocarpa*) constitutes a convenient source. It can also

MANNOSE (*Continued*)—

be obtained from the cellulose of white spruce by hydrolysis with dilute hydrochloric acid, in which case it is accompanied with dextrose. (See Nishida and Hashima on "Glucomannan from 'Konjak'" (*B.C.A.*, 1930, A, 1413); and Vegetable Ivory.)

MANOMETER—Instrument for measuring the tension of gases, steam, etc.; a sort of pressure gauge. See H. W. Melville (*J.C.S.*, 1931, p. 2509).

MANUKA OIL—The essential oil from the leaves and terminal branchlets of *Leptospermum scoparium;* yield 0·37 per cent. by weight; soluble in 10 vols. of 90 per cent. alcohol. It contains 12 per cent. *a*-pinene, 60 per cent. eudesmene and another semiterpene, 6 per cent. citronellol, geraniol, etc., 1 per cent. citronellal and citral, 1 per cent. cineol, and 12 per cent. other constituents; d_4^{25} 0·9179 (W. F. Short, *J.S.C.I.*, 1926, **45**, 96 T).

MANURES—See paper on "The Microbiology of Farmyard Manure," by H. L. Jensen (*B.C.A.*, 1931, B, 312); Fertilizers and Phosphates.

MAPLE SUGAR—See Sugar.

MARBLE—Crystalline limestone. (See Calcium.)

MARC—The refuse material left after extraction or pressure of seeds, fruits, and herbs.

"MARGALITE"—A resinous condensation product, prepared from phenol and formaldehyde, of rapid drying properties, advocated for painting the interiors of concrete tanks wherein to store oils, etc. (See Gums and Resins (Synthetic).)

MARGARIC ACID ($C_{17}H_{34}O_2$)—The substance described under this name as one of the higher fatty acids, melting at 60° C., is now regarded as being, in reality, a eutectic mixture of palmitic and stearic acids.

MARGARINE—A butter substitute, manufactured on a large scale, consisting of fatty acids or oils from various sources, compounded with skim-milk sterilized by heating from 60° to 82° C., and inoculated with the butyric ferment (lactic acid bacilli), carefully grown in milk, in order to give the blended mixture a butter-like odour.

Cotton-seed, palm, cocoa-nut, and arachis oils are largely used, and in some cases animal fats, such as "premier jus" and lard, are admixed with the vegetable oils, so proportioned as to give a m.p. of about 22° to 27° C. Stearine, being more solid at the ordinary atmospheric temperature, is also used when necessary to counteract the more liquid oils and to adjust the desired consistency.

The fats produced by the hydrogenation process (see Hydrogenation, p. 461) from whale, cotton-seed, and other oils, are now also extensively used to replace the animal fats previously employed.

The process of making is somewhat as follows: the milk, after cooling to 10° C., is churned with the melted mixture of fats and oils at a temperature of 25° to 35° C. until thoroughly emulsified, then rapidly cooled, and after maturing (to allow the butyric ferment to do its work), kneaded to expel the excess of water over 16 per cent., which is the

MARGARINE (*Continued*)—

legal limit. It is essential that the oils should be run slowly into the milk in the churn, to produce a fine-grained permanent emulsion of the oil-in-water type, as if the reverse method be used, an emulsion of the water-in-oil type results, and is not so satisfactory. (See Emulsions.)

Certain makes of margarine are not devoid of vitamin content, and a Port Sunlight make is stated to be prepared containing the A and D varieties uniform with butter. The works at Bromboro Port where it is made are described in an illustrated article in the *Ind. Chem.*, 1929, v., 97.

The English production of margarine in 1915 was estimated at 240,000 tons.

(See another article descriptive of the manufacture (*Ind. Chem.*, 1925, i., 393); J. A. Van Dijk (with others) (*Analyst*, 1931, **56**, 544).)

MARIGOLD (Calendula)—The dried florets of *Calendula officinalis* (N.O. Compositæ); a native of France and some southern parts of Europe; used in colouring butter and cheese, adulterating saffron, etc.

"MARINE GLUE" is a cementing composition consisting of rubber and shellac dissolved to a paste in naphtha.

MARJORAM OIL—The essential oil of the aromatic herb *Origanum marjorana* and other species (N.O. Labiatæ), cultivated in Spain, Morocco, and Tunisia, and obtained by distillation. It contains sabinene, terpineol, borneol, and terpenes; is soluble in alcohol and ether, and used for scenting soap, also in perfumery and medicine and by farriers on account of its caustic nature as a stimulating liniment. Its sp. gr. is 0·894 to 0·912 at 15° C., opt. rot. +5° to +18° at 20° C., and ref. ind. 1·4725 to 1·4765 at 20° C. The fresh herb is stated to yield 0·35 per cent. oil.

MARKING INKS—See Inks.

MARKING LABORATORY APPARATUS—See Glass Marking, p. 406.

MARL—Earth consisting of clay, chalk, and sand.

MARMATITE—A ferruginous variety of blende (in which zinc is partly replaced by iron and manganese) occurring in the Broken Hill concentrates. (See W. F. de Jong, *B.C.A.*, 1928, A, 1349.)

"MARMITE"—A food preparation resembling extract of meat prepared from yeast. (See Proteins.)

MAROTI OIL—From the seeds of *Hydnocarpus Wightiana* (Blume); sp. gr. at 25° C. 0·956, sap. v. 199 to 201, and i.v. (Winkler) about 93 to 96.

MARSH GAS—A mixture of methane (CH_4) (a constituent of coal gas) with carbon dioxide and nitrogen, formed in nature by the decomposition of organic bodies under water. (See Hydrocarbons (Methane).)

MARSH'S TEST—See Arsenic (Hydride), p. 59.

MARTENSITE—A transition form of austenite formed during cooling. (See E. Scheil (*B.C.A.*, 1929, A, 1229); "Austenite" and Iron.)

MASS ACTION—Mass means a definite weight of matter, but according to Einstein's theory of relativity, mass and energy are interchangeable. There must be loss of mass when, for example, helium is liberated from its originating material, but this loss, although great when viewed as energy, is not ascertainable by ordinary chemical balances, and in no realizable chemical interaction is there any observable change of mass into energy—that is to say, no loss of matter by weight—but only a relationed redistribution of energy. (See Elements, pp. 305-306; Chemical Interactions, pp. 174-175; Gravitation, p. 419; and Force, p. 368.)

Under constant conditions, the rate of chemical change is proportional to the active masses of the reacting substances, and the active mass may be taken as proportional to the molecular concentration. For example, in the interaction between ethyl alcohol and acetic acid in equivalent proportions (as referred to on p. 175), it ceases when two-thirds of each has been transformed, so that with 1 gramme molecules when equilibrium is reached, the concentration of alcohol and acid is expressed as $= 1 - \frac{2}{3} = \frac{1}{3}$ and that of ethyl acetate and water each $= \frac{2}{3}$.

MASS NUMBER—The hypothetical number of protons in the atom. (See Elements and Light (Mass Spectrography).)

MASS SPECTOGRAPH—See Atoms, Elements, Isotopes, and Light (p. 538).

MASSICOT—See Lead.

MASTIC—See Asphalt, Gums and Resins (p. 426).

MASURIUM (Ma)—Atomic number 43. One of the new elements stated to occur in platinum ores and columbite, of whose chemical characters little is at present known. (See *J.C.S. Abs.*, October, 1925, **2,** 939.)

MATCHES—Splints of wood, sometimes immersed in melted paraffin wax and then tipped by dipping into some igniting compound, of which there are many varieties. Some "safety" types of matches are tipped with a mixture of potassium nitrate or chlorate, potassium dichromate, red-lead, and antimony sulphide, held together with a glue binder, so that when rubbed over a surface of material containing the non-poisonous amorphous form of red phosphorus in admixture with sulphide of antimony with which the striking sides of the match-boxes are covered, they take fire by friction.

In recent years the use of phosphorus has been supplanted by that of sesquisulphide of phosphorus.

According to an invention of M. M. Dessau, matches are waterproofed by incorporating rubber latex with the fulminating material, and then vulcanizing by the Peachey process. (See Rubber.)

"Vestas," or wax matches, only differ from the wooden ones in respect of the nature of the stalks, and "Vesuvians" in respect of the bulbous head, which is formed of some such mixture as charcoal, nitre, sand, and some binding material, tipped with the igniting mixture. A flame-producing device of re-strikable character as a substitute for matches is described in English patent 329,796 of 1929. (See *C.T.J.*,

MATCHES (*Continued*)—

1930, **87**, 84, and 1931, **89**, 89); also J. Missenden on "The World's Match Industry" (*C.T.J.*, August 29, 1924).)

MATLOCKITE—A lead ore of crystal system, No. 4, and sp. gr. 7·2.

MATRINE ($C_{15}H_{24}ON_2$)—An alkaloid contained in the roots of *Sophora flavescens* Ait.

MATTE (**Mat**)—See Copper.

MATTER—Matter is the substance or substances constituting the chemical elements and their compounds of which the universe is composed, capable of assuming three distinct physical states—namely, the fluid, solid, and gaseous. Water can assume the forms of ice and steam, and mercury (quicksilver) can be frozen to a solid and vaporized by heat. The various kinds or modifications of matter are characterized by their properties. Matter is indestructible; only its forms can change.

The electronic changes of matter referred to under various headings have been confined to very minute quantities (less than those usually dealt with in ordinary chemical operations, and inestimable by such methods), and so far not at all applicable to the larger masses dealt with in laboratory or manufacturing processes.

By some physicists, matter is envisaged as one of the forms of energy; F. W. Aston, for example, considers that primordial atoms consist of positive and negative electricity—protons and electrons. (See his Robert Boyle Twenty-sixth Lecture, Oxford University Press, p. 13.) The more or less current view of the ultimate "oneness" of matter was resuscitated by the author of this Encyclopædia as far back as 1871 (*Chem. News*, September 15, 1871). In further reference to this subject it has been reported that by "photographing the behaviour of a hydrogen atom penetrating a calcite crystal, Professor Dempster was able to show that the infinitesimal nucleus of the hydrogen atom is in a state of continuous motion at a tremendous speed. Discussing Professor Dempster's demonstration, Professor Arthur H. Compton, a Nobel Prize winner, said: 'The most important contribution of the twentieth century to physics has been the discovery that the physical world is composed of three kinds of particles—protons, electrons, and photons, and that each of these particles has also the characteristics of waves. The last stage of this work is proof that protons, the positively charged parts of matter, have wave characteristics. It is this completion of the great work of twentieth-century experimental physics which has now been achieved through Professor Dempster's discovery of diffraction of protons by a crystal.' Experiments thus far have been confined to hydrogen, but Professor Dempster is now experimenting with helium." (*The Times*, January 4, 1930.)

Such conclusions are not to be accepted as final. (See C. T. Kingzett on "Material Chemistry and Immaterial Matter" (*C.T.J.*, 1922, **71**, 283); critical article by H. E. A. (*Chem. and Ind.*, 1930, **49**, 491); J. C. Drummond on "Some Aspects of Organic Life" (*J.S.C.I.*, 1927, **46**, 161 T); *The New Conceptions of Matter*, by C. G. Darwin (G. Bell

MATTER (*Continued*)—

and Sons, London); also Atoms, Chemical Interactions, Electrons, Elements, Photons, Protyle, and Radio-activity.)

MAUVE (**Mauveine**)—The first aniline dye prepared in this country. It is a member of the "safranines" group and, among other processes, it can be made by the oxidation of aniline and toluidine with potassium dichromate. It is a crystalline substance of green lustre which dyes mauve, but the colour fades in sunlight. It is used for colouring postage stamps amongst other applications. (See Safranines.)

Me—An abbreviation signifying methyl.

MEASURES—See "Graduation of Measures" by H. V. Renn (*Ind. Chem.*, 1925, i., 515); also Burettes, Pipettes, and Weights and Measures.

MEAT INDUSTRY—Meat extracts are prepared by the digestion of chopped meat in cold water followed by gradual heating, thus extracting about one-eighth part by weight, leaving the insoluble fibrin. They can be concentrated by heat, and contain the extractive matters, salts, and other soluble matters of the meat, while in some cases the fibrin is dried, powdered, and mixed in with the extracts. That is to say, at best they are light and stimulating articles of food prepared in a more digestible fashion than meat itself, which, of course, to those who can digest it, is really preferable as food. Possibly in some cases—according to the method of extraction—there is some hydrolysis of the albuminoid constituents of the meat, thus leading to the production of more soluble and easily digested albumoses or peptones. (See T. Moran (*Chem. and Ind.*, 1932, **51**, 84), Albumins, and Proteins.)

MECONIC ACID—See Opium.

MEERSCHAUM (**Sepiolite or Seafoam**) ($2MgO,3SiO_2,2H_2O$)—A very light amorphous hydrated silicate of magnesium, of sp. gr. 0·8 to 1·0, found in certain alluvial deposits in Asia Minor, Greece, Russia, and elsewhere. As dug from the earth it is soft and soap-like, lathers with water, and is used by the Turks as a soap substitute. It is, as a rule, slightly yellow in colour, and used also for making pipe-bowls, etc. Talc and serpentine are other varieties of magnesium silicate.

"MELANOID"—Proprietary brand of bituminous paints, and of an enamel, for the detection of heat in bearings, etc.

"MELDOLA'S BLUE"—An oxazine dyestuff.

MELILITE—The name of a group of mineral compound silicates, including *gehlenite* ($Ca_2Al_2SiO_7$) and *akermanite* ($Ca_2MgSi_2O_7$), of crystal system, No. 2, and sp. gr. about 3·0. B. E. Warren (*B.C.A.*, 1931, A. 289) gives the formula of one variety as $(Ca,Na)_2(Mg,Al)(Si,Al)_2O_7$.

MELINITE—See Explosives.

MELISSA OIL—Obtained by distillation with water from the plant *Melissa officinalis;* of lemon odour, sp. gr. 0·894 to 0·924, opt. rot. 0° – to +0·30°, and yield 0·01 to 0·1 per cent.

MELISSIC ACID ($C_{30}H_{60}O_2$) M.p. 90° C.—One of the higher members of the normal fatty acids, obtainable from bees-wax. (See Acids, p. 9.)

MELITRIOSE (Mellitose)—See Raffinose.

MELLITIC ACID ($C_{12}H_6O_{12}$ or $C_6(CO_2H)_6$)—Occurs in peat and some deposits of brown coal as so-called honeystone (mellite), or aluminium mellitate ($C_{12}Al_2O_{12},18H_2O$). When pure, it is a white, crystalline body, soluble in water and alcohol, of polybasic character, and can be obtained from lignite or graphite by oxidation with potassium permanganate. Its preparation and derivatives are dealt with by Meyer and Raudnitz (*B.C.A.*, 1930, A, 1436).

MELON OIL—The seeds of the water-melon (*Citrullus vulgaris*), much cultivated in warm countries and to some extent in this country, give an oil of the semi-drying class (varying in yield from 36·8 to 48·1 per cent. on the dry seeds), having a sp. gr. of 0·9218 to 0·9236, acid value 1·3 to 17·8, ref. ind. $n^{40^\circ\mathrm{C.}}_{\mathrm{D}}$ 1·4645 to 1·467, i.v. (Hübl) 115·5 to 124·3, and sap. v. 190·1 to 195·1. The seeds are rich in protein. These figures have reference to supplies from the Kogai seed from Sierra Leone, and the Guna seed from Nigeria. (See *Analyst*, 1925, l., 462.)

MELONITE (Nickel-telluride) (NiTe)—A mineral of crystal system, No. 3, and sp. gr. about 5·0.

MELTING-POINTS—The temperatures at which fusible substances melt, or become liquid—that is, at which their solid and liquid phases are in equilibrium—and as these are affected by pressure they are usually referred to normal pressure (760 mm.). It is to be noted that many mixtures, such as fats and waxes, do not solidify until a temperature several degrees lower than their melting-points is attained; while alloys generally melt at lower temperatures than those of their components.

An improved electrically heated melting-point apparatus for making determinations above 150° C. and for lower temperatures is described by F. A. Mason (*Chem. and Ind.*, 1925, **44,** 577), and a new apparatus alleged to record corrected m.p.s up to 300° S. by J. R. Hosking and W. F. Short (*J.S.C.I.*, 1926, **45,** T, 89); the Dennis m.p. apparatus for organic compounds (*Ind. Chem.*, 1931, vii., 424); S. Avery (*Ind. Eng. Chem.*, June, 1928); and Alloys.

MENHADEN OIL—See Fish Oils.

MENISCUS—The curved surface of a liquid confined in a tube due to capillarity, as shown by a solution contained in a burette or the column of mercury in a barometer; concave when the liquid wets the container, otherwise convex, as with mercury.

MENSTRUUM—Any solvent liquid used for extracting the soluble parts of a material.

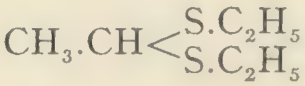
MENTHENE ($C_{10}H_{18}$)—A terpene product obtained from menthol by the elimination of water; it has also been synthesized.

MENTHOL (Mint Camphor) ($C_{10}H_{19}OH$)—A secondary alcohol, being an antiseptic, colourless, crystalline, camphoraceous substance, which deposits from peppermint oil when kept for a long time or cooled to a low temperature. It can be obtained from several varieties of *Mentha piperita*, but is mainly imported from Japan, being chiefly obtained from the peppermint plant, *Mentha arvensis*. The natural menthol is

MENTHOL (*Continued*)—
the lævo variety; m.p. 44·5° C., sp. gr. 0·890, b.p. 215° to 216° C., and sp. rot. $-49°$ to $-50°$. It is soluble in alcohol and ether, and is nearly related to menthene ($C_{10}H_{18}$), which can be obtained from it by elimination of water (as, for example, by the action of phosphorus pentoxide). It can be readily prepared from piperitone and thymol, and is used medicinally, also in perfumery and confectionery. (See McLang (*C.T.J.*, 1926, **79,** 557) and Thymol.)

MENTHONE ($C_{10}H_{18}O$) is a ketone related to menthol ($C_{10}H_{20}O$), and occurs with that substance as a constituent of oil of peppermint; both it and menthol can be produced chemically from the oil of *Eucalyptus dives* and *E. piperita*. It boils at 207° C., and is easily converted into thymol. According to S. Komatsu and M. Kurata (*J.C.S. Abs.*, 1925, I., 1290), when *l*-menthone is passed slowly through a glass or silica tube at 300° C. in presence of copper acting as a catalyst, it yields 70 per cent. thymol, 22 per cent. cymene, and 3 per cent. menthene. (See J. Read (*Chem. and Ind.*, 1927, **46,** 871); F. Grove-Palmer (*Ibid.*, 1931, **50,** 197); and Thymol.)

MERCAPTALS (**Thio-Acetals**)—Sulphur compounds being analogues of acetals, such as



$$CH_3.CH<\begin{matrix}S.C_2H_5\\S.C_2H_5\end{matrix}$$

(See Acetals.)

MERCAPTANS (**Thio-Alcohols**)—A group of liquid, inflammable, organic compounds containing the HS group, analogous to the monohydric alcohols. They have a very sharp, unpleasant (garlic-like) odour, are insoluble in water, but soluble in alcohol. Their relationship to alcohol is shown by the two illustrative formulæ: C_2H_5HO (ethyl alcohol), C_2H_5HS (ethyl thio-alcohol). They may be prepared by several methods—the ethylic compound, for example—by heating alcohol with phosphorus pentasulphide, the oxygen being thus replaced by sulphur; or by heating a mixture of an alkyl halide with potassium hydrosulphide.

The thio-ethers or alkyl sulphides, such as ethyl sulphide, $(C_2H_5)_2S$, are neutral volatile liquids devoid of acid character.

MERCAPTIDES—Metallic derivatives of mercaptans in which hydrogen of the HS group is replaced by a metal. (See Drummond and Gibson on "Co-ordinated Mercaptides," *J.C.S.*, 1926, p. 3073.)

MERCERIZATION—See Cellulose and Silk Substitutes.

"MERCEROL"—See Wetters.

MERCUROCHROME—A dye of the phthalein series used in treatment of infections of the genito-urinary tract.

MERCURY (**Hydrargyrum, Quicksilver**) (Hg) **and its Compounds**—Atomic weight, 200·6; sp. gr. at 0° C., 13·56; m.p. $-38·87°$ C.; b.p., 357·33° C. Mercury occurs in nature to some extent in the free or globular state admixed with its ores (particularly the sulphide), of which *cinnabar* (HgS) is the best known; also in the mineral *turpeth* as a basic sulphate (Hg_3SO_6 or $HgSO_4,2H_2O$). Supplies of mercury ores

MERCURY (*Continued*)—

occur in Algeria, Austria, Italy, Mexico, New Zealand, Spain, California, Nevada, Oregon, China, Chile, Japan, etc. The world's production in 1913 was 4,200 tons, and was more recently estimated at 3,300 tons, Italy and Spain providing the greater part; but according to the U.S. Commerce Report, the production in 1927 amounted to 71,000 flasks of 75 lbs. each only—viz., 2,377 tons.

The metal is made from the natural sulphide by roasting the ore, whereby the sulphur is burnt off as sulphur dioxide (SO_2), or by heating the ore mixed with lime in closed retorts. In this last-named process the lime combines with the sulphur, whilst the mercury is liberated and distils over as vapour, which is then condensed. In the "Thornhill" process of extraction, the natural sulphide is dissolved in a 4 per cent. solution of sodium sulphide and 1 per cent. caustic soda, and the mercury is precipitated therefrom by aluminium turnings.

It is a bright, silver-coloured, liquid metal which solidifies at about $-39{\cdot}7°$ C. in crystal system, No. 1; assumes a crystalline (rhomboidal) structure at $-80°$ C., and readily combines with many other metals, forming alloys or combinations which are called *amalgams*. Its vapour and all its compounds are poisonous, and cases of poisoning have been attributed to silver-amalgam dental fillings.

A sublimation mercury still for the purification of the metal is described by K. Hickman (*Chem. and Ind.*, 1929, **48**, 366) and laboratory methods for its purification are described by Burrows Moore (*Ind. Chem.*, 1932, viii., 63) and by E. Newbery (*Ibid.*, 1929, v., 289), in which latter it is shown that the electrolytically produced metal is the most reliable as regards purity.

Mercury is supposed to have seven isotopes, and their partial separation can be effected, as recently claimed, by evaporating the metal at low pressure and condensing the evaporated atoms on a cooled surface, the density of the condensed mercury being slightly lower than that of the residual metal. (See Transmutation.)

Respecting the solubilities of various metals in mercury, see Tammann and Hinnüber (*B.C.A.*, 1927, A, 304). Apart from its uses in the construction of thermometers and barometers, it is used in making mirrors, amalgams, extraction of gold from its ores, the manufacture of vermilion, in various electrical applications, and in the generation of power.

Oxides of Mercury—When submitted to long heating in the air above 300° C., the metal is slowly converted into the red mercuric oxide (HgO), and when this oxide is heated to redness it is again decomposed into its constituent elements. The red oxide is used as a pigment and for making anti-fouling marine paints. The yellow variety, as obtained by precipitation from a mercuric solution by sodium hydroxide, is stated to have the same crystalline form, and is also used as a pigment.

Mercury forms several other combinations with oxygen, the salts of mercury corresponding to the lower oxide (Hg_2O) being styled "mercurous," while those corresponding to the higher oxide (HgO) are classified as "mercuric" compounds.

MERCURY (*Continued*)—

The lower oxide (Hg_2O) is precipitated in a dark brown form when sodium hydroxide is added to a mercurous salt in solution; it is unstable, and when exposed to light or gently heated it is converted into mercury and the higher oxide.

Mercurous Chloride (*calomel*) (Hg_2Cl_2) is a white, crystalline body, insoluble in water, used in medicine. It is found in native form as horn-mercury (*horn-quicksilver*).

Mercurous Nitrate ($Hg_2NO_3)_2$) can be obtained in colourless monosymmetric crystalline form (containing two molecules of associated water). It is soluble in water acidified with cold dilute nitric acid, but is not very stable in character.

Mercurous Sulphate (Hg_2SO_4) is a white, crystalline compound very slightly soluble in water.

Mercuric Chloride ($HgCl_2$), or *corrosive sublimate,* is a white, crystalline, poisonous substance, soluble in water, and of powerful germicidal character, for which reason it is used as a wood preservative, also by taxidermists in preparing the skins of animals, and by surgeons (in dilute solutions) as an antiseptic wash, etc.

Mercuric Sulphate ($HgSO_4$) is a white, crystalline substance, insoluble in water, used in the preparation of the two chlorides and in the extraction of gold and silver from roasted pyrites.

Mercuric Iodide (HgI_2) is insoluble in water and is dimorphous; when heated to 150° C. the scarlet tetragonal crystals are changed into another and yellow rhombic crystalline form, but upon being lightly touched is at once retransformed into the original state.

Mercuric Nitrate ($Hg(NO_3)_2 2H_2O$) is a crystalline, deliquescent soluble salt used in medicine and felt manufacture. (See Millon's Test.)

Mercuric Sulphide (HgS), as obtained by the precipitation of a mercuric salt with hydrogen sulphide, is black and insoluble; but when washed, dried, and sublimated, it becomes red, forming the so-called "vermilion," in which form it is manufactured for use as a pigment and for colouring sealing-wax (red).

Mercuric Sulphocyanate ($Hg(SCN)_2$) is a white, poisonous and explosive body used in preparing so-called "Pharaoh's serpents" and in photography. (See Thiocyanides.)

Mercuric Cyanide ($Hg(CN)_2$) is colourless, crystalline, soluble in water, and used for making cyanogen gas and in photography.

Mercury Fulminate—See Fulminating Mercury.

MERCURY BOILER—See Steam Generation.

MERCURY MICRO-LAMP—An electric light of a few definite colours, produced by passing an electric current through mercury vapour, and used for illumination of microscopic specimens. "The K.B.B. microscope illuminant" is a form of mercury lamp of durable character, and in addition to its advantages offered in the visible spectrum, is one of the richest sources of ultra-violet radiation. Some of the uses to which

MERCURY MICRO-LAMP (*Continued*)—
this lamp has been put are detailed in the Government Analyst's Report for 1928 (*Analyst*, 1929, **54**, 545); see also Ultra-Violet Rays.

MESO—A prefix used to distinguish some stereoisomers or to indicate the position of certain carbon atoms in polycyclic bodies.

MESO-THORIUM—See Thorium.

"**META**" (**Metaldehyde**) $(C_2H_4O_3)_3$ is a white, crystalline subject which can be used as a solid fuel and may possibly replace denatured alcohol—clean, portable, and free from danger—produced by the polymerization of acetaldehyde. It may be polymerized into two trimolecular compounds—viz., the *cis* compound (paraldehyde, which is a harmless and efficient mild hypnotic of b.p. 120° C. and soluble in water) and the *meta* compound or *trans* modification which sublimes at about 110° C. and is insoluble in water. In making it, acetylene is converted into acetaldehyde and this into paraldehyde which is distilled with dilute mineral acid; the liberated acetaldehyde is condensed and treated in cast-iron vessels at 15° C. with sulphuric acid (as a catalyst), the meta compound being thus precipitated. The heating value of the compressed compound is 6,136 calories per kilo as against 7,065 per kilo, or 5,162 calories per litre of alcohol.

META COMPOUNDS—Substitution products derived from benzene in which the substitutory radicals or groups are constitutionally placed in certain definite positions in the nucleus—meta-cresol, for instance (1 to 3 substitution). (See also Metameric.)

META-CRESOL—See Cresol.

META-FILTRATION—See Filters.

META-NITRANILINE (C_6H_4,NO_2,NH_2)—A yellow crystalline intermediate, soluble in alcohol and ether.

META-PHENYLENE-DIAMINE $(C_6H_4(NH_2)_2)$—A colourless, crystalline intermediate, soluble in water, alcohol, and ether.

META-PROTEINS—Early products of the hydrolysis of proteins, retaining many of their characters but not coagulable by heating.

META-STANNIC ACID—See Tin Compounds.

META-TOLUYLENE-DIAMINE—See Toluylene-Diamine.

METABOLISM—The various changes affecting the tissues of the body and energy resulting from the conversion of food in living organisms.

METALLIC CARBONYLS—Volatile and practically colourless liquid compounds of metals with carbon monoxide, the cobalt, nickel, and tungsten compounds being $Co(CO)_4$, $W(CO)_6$, and $Ni(CO)_4$. Molybdenum carbonyl is probably $Mo_5(CO)_{26}$, and ruthenium carbonyl $Ru(CO)_2$ (singular in being soluble in water). An iron, yellow, viscid, poisonous liquid ($Fe(CO)_5$) of b.p. 103° C. is known; it is soluble in benzol, and can be used as an anti-knock agent in liquid fuels for internal combustion engines. Other compounds include the compositions $Fe_2(CO)_9$ and $Fe(CO)_4$. The vapours of metallic carbonyls are poisonous. (See

METALLIC CARBONYLS (*Continued*)—

W. E. Wallis (*Chem. and Ind.*, 1929, **48,** 290); R. L. Mond (*B.C.A.*, 1929, B, 471); and *J.S.C.I.*, 1930, **49,** 271 T, 283 T, and 287 T; Hieber and Bader (*B.C.A.*, 1930, A, 875); Hieber and Becker (*B.C.A.*, 1930, A, 1008); Friend and Vallance (*J.C.S.*, 1930, p. 718); and Hieber and Vetter (*B.C.A.*, 1931, A, 1255).)

METALLIC NITROXYLS—Combinations of metals with nitric peroxide, such as copper nitroxyl (Cu_2NO_2), formed by the action of nitric peroxide on reduced metallic copper.

METALLIC ORGANIC Compounds—See Organo-metallic Compounds.

METALLIC SOAPS—See Soaps.

METALLISATION—See Metals.

METALLOGRAPHY—Metallography is the study of the constitution and internal structure of metals and alloys, as carried out by microscopical and physical means, including the thermal features when heated or cooled, measurements of expansion and contraction, electrical resistances and solution potentials, supplemented by chemical examination. The value of chemical tests is illustrated by the fact that an alloy of 56·5 per cent. copper and 43·5 per cent. zinc is immune from attack by nitric acid, while both individually are rapidly dissolved.

METALLOID—A term applied to those elements, such as arsenic and selenium, which are not decidedly metallic, but occupy a position on the borderland between the absolutely metallic and non-metallic elements.

METALLURGY—The art of extracting and working in metals by the applications of chemical and physical knowledge. (See "Ferrous Metallurgy and Corrosion" (*Chem. and Ind.*, 1927, **46,** 209); report of discussion on paper by W. Cullen on "Non-Ferrous Metallurgy" (*C.T.J.*, 1929, **84,** 50); "The Chemist in the Metallurgical Industries" (*Ind. Chem.*, 1930, vi., 435); "Spectrum Analysis in Metallurgy," by J. R. Green (*Chem. and Ind.*, 1927, **46,** 741 and 764).) Books by E. L. Rhead (Longmans, Green and Co., London); Robert Hadfield (Chapman and Hall, Ltd., London); Bamford and Harris (Chapman and Hall); G. Patchin (Baillière, Tindall and Cox, London); *Select Methods of Metallurgical Analysis,* by W. A. Naish and J. E. Clannall (Chapman and Hall); *Metallurgy of White Metal Scrap and Residues,* by E. R. Thews (Chapman and Hall). See also the publications of the British Non-Ferrous Metals Research Association, 1920-1931.

METALS—The metallic elements as a class are capable of taking a high polish: gold, copper, and platinum may be polished and burnished to a very high degree—much more than iron, lead, and arsenic. Some are much more *ductile* than others, and can therefore be easily drawn out into wire; copper in this form is largely used for telegraphic purposes. Others are of a *malleable* character—that is to say, can be easily beaten into any desired shape—lead, for example; while gold and several other metals can be hammered into extremely thin sheets—gold leaf, for example. (See Gold.)

Most metals are good *conductors* of heat, sound, and electricity, and

METALS (*Continued*)—

at a temperature approaching absolute zero, pure metals lose practically all electrical resistance and become nearly perfect conductors.

From the point of view of crystal chemistry, metals are described as intermediate in position between ionic and homopolar substances. (See J. D. Bernal, *Trans. Faraday Society*, 1929, **25**, 367.)

Some metals combine by diffusion and solid masses can be obtained under pressure, as in the making of tungsten wire from the powder form.

There are great differences between the hardness, brittleness, weight, tensile strength, and other properties of the various metals, and it has been demonstrated that the corrosion of metals is mainly, and probably entirely, due to electro-chemical changes.

The following table comparing the production within the Empire with the estimated normal consumption apart from special war demands is taken from a British official report issued some years ago:

	Production (Tons).	Consumption (Tons).
Iron	4,600,000	7,000,000
Tin	5,100	21,000
Lead	17,000	179,000
Zinc	4,800	185,000
Copper	140	130,000
Manganese (ore) ..	4,500	400,000
Wolfram	260	4,000

References: H. O'Neill on "The Hardness of Metals" (*Chem. and Ind.*, 1929, **48**, 487); J. E. Malam on "Hardness Tests for Metals" (*B.C.A.*, 1928, B, 715); B. P. Haigh on "Chemical Action in Relation to Fatigue in Metals" (*Chem. and Ind.*, 1929, **48**, 220); Bradley Stoughton on "Metals Used in Aircraft Construction" (*Chem. and Ind.*, 1929, **48**, 1189); A. K. Graham on "Dipping Copper and Brass" (*C.T.J.*, 1927, **80**, 431); McMyn and Edge on "Case-Hardening by Cyanide Method" (*C.T.J.*, 1931, **88**, 495); on "Acid-Resisting Metals" (*Chem. and Ind.*, 1931, **50**, 474); S. Skowlonski on "The Electrolytic Refining of Metals" (*C.T.J.*, July 4, 1924); information respecting single metallic crystals (*Chem. and Ind.*, 1927, **46**, 599); "Atmospheric Corrosion of Metals," by J. C. Hudson (3rd Report to Atmospheric Corrosion Research Committee, with discussion, *Faraday Society*, May 23, 1929), and by W. H. J. Vernon (*Trans. Faraday Soc.*, No. 121, Vol. xxvii., part 6, June, 1931); *The Corrosion of Metals*, by U. R. Evans (E. Arnold and Co.); also Alloys, Brinell's Ball Test, Corrosion, Hardness, and Ores.

Colouring of Metals can be produced by many chemical methods using various reagents, and by electrical ones, such as the deposition of copper upon iron or zinc surfaces by immersion in a dilute solution of cupric sulphate. Again, pickled zinc, when immersed in a dilute solution of copper tartrate and caustic soda, assumes a colouring (from violet to purple-red) which can be arrested at any stage. By heating metals to various temperatures, the surfaces of many can be coloured by

METALS (*Continued*)—

oxidation, a greater range of colouring being realized by first of all treating them with various chemical reagents. These temper colours are possibly due to interference of light reflected in a similar manner to Newton's rings from the two surfaces of a film of a surface compound. (See "Note on Temper Colours," by R. C. Gale, *J.S.C.I.*, 1924, **43**, 349 T; U. R. Evans (*Chem. and Ind.*, 1926, **45**, 211); H. Kurrein (*Ind. Chem.*, 1929, v., 538); and *Chemical Colouring of Metals*, by S. Field and S. R. Bonney (Chapman and Hall, London).)

Gun-barrels are bronzed by rusting of the barrels while the ends are plugged, the rust being converted into magnetic oxide by boiling in water through which air is passing. The commoner bronzing of gun-barrels is done with compounds of antimony. Iron, steel, and cast-iron articles can be made dull black by electrically treating them in a caustic soda solution, whereby a sodium ferrate solution is obtained and a coating of magnetic oxide (Fe_3O_4) results, which is not capable of absorbing oxygen, although the articles are not thus rendered entirely rust-proof. It has been pointed out by J. D. Bengough and H. Sutton that the resistance of aluminium to corrosion due to the presence of a protective film of oxide can be greatly increased by anodic oxidation.

See "Some Properties of Protective Films on Metals," by E. S. Hedges (*Chem. and Ind.*, 1931, **50**, 21 and 768); "The Production of Oxide Films on Copper," by U. R. Evans (*J.C.S.*, 1925, cxxvii., 2484); W. H. J. Vernon (*J.C.S.*, 1926, p. 2273); "The Porosity of Metals," by U. R. Evans (*J.C.S.*, 1927, p. 1020); Copper (p. 238), Corrosion, Electro-plating, Paints, and Rustless Iron and Steel.

Metal Spraying—A process of metal spraying is as follows: A wiring of the metal is pulled into a pistol fed with oxygen and a combustible gas under pressure, and also with compressed air, and in this way minute particles of the wiring are projected from the melting end in the form of spray. Any metal obtainable in wire form and fusible in the oxyhydrogen flame can be used for spraying on to surfaces of paper, stone, concrete, porcelain, leather, celluloid, and various fabrics, wood, or metal. Metal surfaces to be thus coated are first of all roughened by a sand-blast to ensure adhesion, and coatings of any desired thickness greater than 0·02 m.m. may be made, 0·05 generally sufficing for rust prevention. A development of the coating process has been described in which the wire is fed into an acetylene-oxygen flame and the metal blown by means of compressed air on the receiving surface (R. L. Binder, *B.C.A.*, 1930, B, 951). The surface thus produced is always matte, but may be polished, if desired, and is a good one for paints. Metal dust or powder can also be used in another apparatus, and any non-ferrous metal may be applied to any ferrous metal, or *vice versa*. The process is employed for the protection of certain portions of ships and propellers; among other applications, for the zincing of rail-ends and fish-plates, and for connecting purposes on electric railways, thus obviating the necessity for copper connections and continual cleaning. A method for producing homogeneous lead linings of somewhat similar

METALS (*Continued*)—

character has been recently developed, a lead wire being melted and atomized by means of a pistol charged with carbon-dioxide heated to 350° to 400° C. (See *Chem. and Ind.*, 1929, **48,** 1069; E. S. Hedges on "Some Properties of Protective Films on Metals" (*Ibid.*, 1931, **50,** 21); and S. Wernick on "Corrosion" (*Ind. Chem.*, 1928, iv., 183).)

Metal Pickling—See Galvanizing.

Metal Recovery from waste materials. (See references under Waste.)

"Sherardizing," or vapour galvanizing, is said to be best effected by heating the subject-metal with zinc dust in a closed vessel at about 370° to 380° C. (which is below the melting-point of zinc, 419° C.) for about half an hour, thus producing in respect of iron an 8/92Fe/Zn alloy penetrating to a depth of about 0·002 in. and imparting to the metal great resistance to corrosion. When it is specified that the work is to pass the "Preece" test for corrosion (immersion in solution of copper sulphate without the deposition of bright copper), a thin layer of pure zinc must be built up above the surface of the original metal. The zinc dust can be replaced by zinc-iron alloy $FeZn_{10}$.

The general process is applicable to iron and many other metals, and used in respect of small articles such as frames, table-tops, panels, trays, vases, electric-light fittings, etc. In Schoop's process the metal is sprayed over the subject-body to be coated at a high velocity.

Calorizing is really a development of "sherardizing," and is a process for the surface impregnation of steel, iron, copper, brass, nickel, etc., with aluminium, thus forming a homogeneous alloy to a certain depth. This is ordinarily effected by placing the subject metal in an air-tight retort charged with a mixture of finely divided aluminium and alumina, and heating to from 900° to 1,000° C. in a reducing current of hydrogen. The alloy thus produced is rich in aluminium, and on subjection to high temperatures under working conditions, the aluminium penetrates or diffuses through into the metal, an outer coating of aluminium oxide forming a protective surface. It is alleged that the homogeneous alloy will resist oxidation up to 1,800° F. (982·2° C.). The "Meker" process employs coatings with powdered Al_3Fe mixed with about 0·7 per cent. of aluminium chloride and heat treatment, and is stated to give more satisfactory results. (See H. N. Bassett (*Ind. Chem.*, 1930, vi., 241).) Calorized non-ferrous metals, such as brass, copper, and nickel, are excellent non-corrosive materials, resistant to oxidation at high temperatures and to acid liquors.

"Calmet" is a special alloy of the chromium-nickel class for temperatures higher than 950° C.

"Stelliting"—A process of treating metallic surfaces such as varieties of iron and steel with an alloy consisting chiefly of chromium, tungsten, and cobalt by means of the oxy-acetylene blow-pipe. The "stellited" metal finds many useful applications; for example, in making bars and plates for use in the manufacture of cement and as a

METALS (*Continued*)—

non-corrosive material in making dry batteries, dies, and machine parts. (See *C.T.J.*, 1926, **79,** 530.)

(See Corrosion, Diffusion, Passivity, "Stellite," and Welding.)

TABLE OF MELTING OR FUSING POINTS OF SOME IMPORTANT METALS, THEIR SPECIFIC GRAVITIES AND COEFFICIENTS OF EXPANSION × 10^6

Aluminium	658° to 658·5° C.	2·7	24·1
Antimony	630° to 630·5° C.	5·73	—
Bismuth	270° to 271° C.	9·80	—
Cadmium	321° C.	8·65	—
Chromium	1,550° C.	6·92	—
Cobalt	1,490° to 1,530° C.	8·8	—
Copper	1,083° to 1,084° C.	8·65–8·95	17·2–17·9
Gold	1,063° to 1,064° C.	19·32	—
Wrought iron	1,600° C.	7·80	12·3
Pure iron	1,505° C.	7·86	12·3
Lead	327° to 327·4° C.	11·4	29·5
Magnesium	650° C.	1·75	—
Manganese	1,245° to 1,260° C.	7·4	—
Mercury	39·7° C.	13·56	—
Nickel	1,452° to 1,484° C.	8·9	13·3
Silver	961° to 962° C.	10·5	—
Tin	232° C.	7·2	—
Zinc	419° to 419·4° C.	6·9	32·0
Platinum	1,771° ± 2° C.	21·5	—
Steel	about 1,350° to 1,375° C.	about 7·60 to 7·80	—
Muntz metal			19·8
Stainless steel			11–11·7

METAMERIC—Substances which have the same molecular weights and identical percentage composition, but are of different types, properties, and structure, and furnish different products by chemical changes—for example, acetone, $CO(CH_3)_2$, and allyl alcohol, $C_3H_5(HO)$. (See Isomerism.)

METAMORPHISM—The changes in minerals (rocks) of their chemical and physical characters under the influences of heat, pressure, and interaction.

"METASIL"—A filtering material consisting of kieselgühr treated in some special manner.

METASTABILITY—A state of existence of substances illustrated by supersaturated solutions; again, by fluids capable of maintaining the liquid state below their freezing-points, and others of allotropic character persisting below or above their transition temperatures. Kesner has expressed the view that the properties of activated nitrogen are to be attributed to the presence of nitrogen atoms along with "metastable" molecules (see editorial article, *Chem. and Ind.*, 1930, **49,** 159), and

METASTABILITY (*Continued*)—
H. H. Gray in the same issue of that journal has, in a letter, pointed out that metastable material will react, while stable material will not. The addition of some of the same substances in their stable phases effects transformation. (See "Messel Memorial Contribution," by E. Cohen (*Chem. and Ind.*, 1929, **48,** 162-169).)

METEORITES—Mineral substances (aërolites) of meteoric origin which have fallen on the earth's surface, some of iron or iron alloyed with nickel; many others are composed of silicates or of the various elements entering into the composition of terrestrial minerals. Most of them are fused on their surfaces, doubtless brought about by the high temperature induced by their rapid passage through the atmosphere.

METERS—Instruments for measuring quantities of gases and liquids. One such appliance for measuring corrosive liquids is known as the "Nordac" syphon acid meter. (See Recorders.)

METHANE (CH_4)—See p. 453 and J. Brown (*B.C.A.*, 1931, B, 1003).

METHANOL—See Alcohol (Methyl).

METHYL—The monovalent (univalent) radical CH_3; to add to or substitute which in a compound is termed "methylation." The apparent production of free methyl has been the subject of experiments by Paneth and Hofeditz (*B.C.A.*, 1929, A, 788). (See Alcohol (Methyl), p. 20.)

METHYL ACETATE—See Esters.

METHYL ALCOHOL ("Methanol")—See Alcohols and Synthol.

METHYL ALDEHYDE—See Formaldehyde.

METHYL ANTRANILATE—See Neroli Oil.

METHYL BENZOATE (Essence Niobe)—See Esters.

METHYL BLUE—See Aniline and Dimethylaniline.

METHYL BROMIDE (CH_3Br)—A colourless volatile liquid of sp. gr. 1·732, b.p. 4·5° C.; soluble in alcohol and ether; prepared by action of bromine on methyl alcohol in presence of phosphorus, followed by distillation; used for rendering ethyl and methyl chlorides non-inflammable.

METHYL CHLORIDE (Chloromethane) (CH_3Cl)—A colourless gas of ethereal odour and b.p. 23·7° C.; used in medicine, the extraction of perfumes from flowers, and for refrigeration; prepared among other methods by the action of hydrochloric acid gas on warm methyl alcohol containing half its weight of zinc chloride in solution. It is soluble in water and alcohol and can be rendered non-inflammable by suitable admixture with methyl bromide. (See S. R. Carter and N. J. L. Myson, *J.S.C.I.*, 1927, **46,** 31 T.)

METHYL CINNAMATE ($C_6H_5CH.CHCO_2.CH_3$) occurs in varying balsamic products, and is prepared from cinnamic acid and methyl alcohol in the presence of sulphuric acid, followed by distillation. It is a colourless crystalline substance, of m.p. 36° C., b.p. 259·6° C.; soluble in alcohol and ether, and used for flavouring and in perfumery.

METHYL ETHER—See Ethers, p. 322.

METHYL-ETHYL-KETONE ($CH_3.CO.C_2H_5$)—A colourless liquid, of sp. gr. 0·808 and b.p. 81° C.; formed by oxidation of secondary butyl alcohol, and used in making smokeless gunpowder.

METHYL IODIDE (CH_3I)—A colourless liquid halogen derivate, of sp. gr. 2·293 and b.p. 45° C., prepared by interaction of methyl alcohol, sodium iodide, and sulphuric acid, followed by distillation; soluble in alcohol and used in medicine.

METHYL RUBBER—See Rubber.

METHYL SALICYLATE ($C_6H_4(OH)COO,CH_3$)—The principal constituent of oil of wintergreen. A colourless liquid, of sp. gr. 1·186 and b.p. 222·2° C., soluble in alcohol and ether. Chemically, it is the methyl ester of salicylic acid.

The artificial oil of wintergreen is prepared by heating a mixture of methyl alcohol and salicylic acid in presence of sulphuric acid, followed by distillation. It is used in medicine and for flavouring purposes. (See Gaultheria Oil.)

METHYL SULPHONAL—See "Trional."

METHYL VIOLET—A synthetic dye. (See Aniline.)

METHYLAMINE—See Amines.

METHYLATED SPIRITS—Was at one time a mixture of 9 parts ethyl alcohol of sp. gr. 0·920 with 1 part of wood-spirit, but is now a mixture of alcohol denatured with other substances, such as benzine, naphtha, pyridine, or diethylphthalate, to render it unfit for consumption, but yet available for certain chemical purposes—*e.g.*, in manufacturing spirit varnishes, and for use as an alcoholic solvent and fuel.

Denatured Alcohols—

Industrial Methylated Spirits must consist of 95 parts by volume of spirit and 5 parts wood naphtha.

Industrial Methylated Spirits (*Pyridinized*)—Same as above, plus $\frac{1}{2}$ of 1 part of crude pyridine to each 100 parts of the volume of the mixture.

Mineralized Methylated Spirits must consist of 90 parts by volume of spirits, $9\frac{1}{2}$ parts wood naphtha, and $\frac{1}{2}$ part of crude pyridine; in addition to every 100 gallons of above mixture, $\frac{3}{8}$ of 1 gallon of mineral naphtha (petroleum oil), and not less than $\frac{1}{40}$ of 1 oz. by weight of powdered aniline dye (methyl violet). In the year ended March 31, 1925, 3,804,138 gallons industrial methylated spirits were used in making soaps, hair-washes, cattle medicines, horticultural preparations, embrocations, disinfectants, collodion, photographic applications, the manufacture of various chemicals, etc. (For other and later details see "The Methylated Spirits Regulations," 1925 and 1930, and *C.T.J.*, 1930, **87,** 535.)

METHYLATION—See Methyl.

METHYLENE (the Radical Group) (CH_2)—The hypothetical first member of the olefine series of hydrocarbons.

METHYLENE BLUE (Tetramethyl-Thionate Hydrochloride) ($C_{16}H_{18}N_3SCl$) is used as a bacteriological stain and as a standard solution in volumetric analyses; also in medicine and in dyeing cotton yarns and wool. (See F. W. Atack (*C.T.J.*, 1925, **77**, 387) and Aniline.)

METHYLENE CHLORIDE (Dichloromethane) (CH_2Cl_2) is a colourless, volatile liquid, of sp. gr. 1·2615 and b.p. 42° C., soluble in alcohol and ether, used as a local anæsthetic, and prepared by the chlorination of methyl chloride, followed by distillation.

"METOL"—A trade name for monomethyl-paraminophenol hydrochloride, or monomethyl-para-amino-phenol sulphate, used as photographic developers. As prepared in several ways they are quite innocuous, but unless carefully purified, very irritating to the skin and raise blisters. The sulphate preparation can be prepared by heating quinol with aqueous methylamine under pressure, and pouring into sulphuric acid; it is somewhat soluble in water.

METRE—See Weights and Measures.

METRIC SYSTEM—See Weights and Measures.

METROSIDEROS—Essential oils. (See Roy Gardner (*J.S.C.I.*, 1931, **50**, 141 T).)

MEXICAN POPPY OIL—See Argemone Oil.

"MIANIN"—A chloramine disinfectant. (See Chloramine.)

MICA—The somewhat general name of a number of lustrous, laminated, hard, silicate minerals of *micaceous* character, including *muscovite,* or common mica ($3Al_2O_3,K_2O,6SiO_2,2H_2O$), of crystal system, No. 5, and sp. gr. 2·7 to 3·0; hardness about 2; characterized by their cleavage in one direction. For the most part they are hydrous silicates of aluminium of varying and complicated composition, some being associated with potassium, lithium, magnesium, iron, etc. The chief supplies come from India, Canada, Sweden, and the United States, but there is a growing industry in Brazil, Madagascar, and the Argentine. Muscovite is readily hydrolysed by heating with water, and gradually approaches kaolinite in composition.

Mica finds use as a substitute for glass in windows of motor-cars, etc., lanterns, and the front of stoves, being non-inflammable and not liable to fracture with changes of temperature. It would appear to have some value as a fertilizer in soils deficient in potash content. The variety known as *muscovite* is a potash mica and occurs at places in New Hampshire and China in large sheets of a yard or more in width, and it also occurs abundantly in Sweden and Norway. Its high electrical resistance and other properties have led to very extensive applications in the electrical industries. (See "The Mica Industry" (*C.T.J.*, 1926, **78**, 31, and 1927, **80**, 361); J. Jakob (*B.C.A.*, 1930, A, 1016, and 1931, A, 1266); "Electrical Properties of Micas" (J. Franklin Inst., September, 1931); Biotite, Lepidolite, and Phlogopite.)

MICA BOARD or "MICANITE"—the subject of an important industry in the United States—is prepared from scrap mica, the cement used being shellac. India possesses a monopoly in production of shellac, and mica abounds in that country.

MICELLES—See Cellulose (p. 158) and Colloid Chemistry (p. 223).

MICRO-BALANCE—See Balances.

MICROBES or MICRO-ORGANISMS—See Bacteria.

MICRO-CHEMISTRY, as originated and developed by Pregl, deals with minute amounts of substances and finds applications in various reactions and analyses, in the identification of some crystalline bodies, colloid chemistry, and biochemical work. It involves the use of delicate microscopes and balances, the average amount of material required being about 4 milligrams. (See W. Garner (*Ind. Chem.*, 1928, iv., 28, 232, 357, and 410; *Ibid.*, 1929, v., 58); "Micro-analysis of Metal Plating" (Strebinger and Holzer, *Analyst*, 1930, **55,** 719); "Micro-chemical Practice," by F. Ernich (*Analyst*, 1931, **56,** 138); *C.T.J.*, 1932, **90,** 122; "New Micro M.P. Apparatus," by Kofler and Hilbek (*Analyst*, 1932, **57,** 130); Balances and Macro-chemistry.)

MICRO-COMBUSTION—See Combustion.

MICROCOSMIC SALT (Sodium-Ammonium Phosphate)—See p. 833.

MICROMETER—Instrument used in conjunction with a microscope to measure small distances, angles and diameters.

MICRON—A linear measure equal to $\frac{1}{1000}$ part of a millimetre—the limit of microscopic visibility. Smaller particles are known as sub-microns.

MICROPHONE—An instrument which magnifies sound.

MICROPLASTOMETER—Instrument to study that part of the plastic flow curve of oils, paints, and varnishes that is due to "slippage," and for the determination of the viscosity and yield value. (See Green and Haslam, *B.C.A.*, 1925, B, 680.)

MICROSCOPY—Microscopes are instruments so constructed as to magnify objects larger than one five-thousandth of a millimetre. When made with only one lens, the instrument is termed a simple microscope, but when fitted with two or more it is known as a compound microscope. Among the many important uses of these instruments may be mentioned their application to the examination of crystals, yeasts, paper pulps, the suitability of moulding-sand for fine castings, cotton fibres, pigments, the cohesion and segregation of metals, etc.

The ultra-microscope is one of high power, so arranged that by the aid of intense localized light, the intensity of reflection of the substance under examination is greatly increased, thus correspondingly increasing the power of vision. This is effected by dipping the object-glass of the microscope into the subject liquid as contained in its glass cell, and allowing a powerful beam of light from the sun or an arc lamp to be focussed by a lens on the liquid just below the microscope. In this way, the light that is scattered from the floating particles causes them to appear as bright specks. Particles as small as 1·7 millimicrons in diameter have been measured by this means, which finds useful application in the study of colloid chemistry. (See Micron.)

MICROSCOPY (*Continued*)—

References: A survey of the chemistry and application of a selection of microscopic stains (dry), by T. H. Fairbrother (*Ind. Chem.*, 1926, ii., 101); *Practical Chemistry by Micro-Methods*, by E. C. Grey (Heffer and Sons, Cambridge); *The Microscope and its Revelations*, by W. B. Carpenter (J. and A. Churchill); *A Handbook of Chemical Microscopy*, by Chamot and Mason (Chapman and Hall); *Practical Photomicrography*, by J. E. Barnard and F. V. Welch (E. Arnold and Co.); and *Recent Advances in* (*Biological Applications*), edited by A. Piney (J. and A. Churchill).

MICROTOME—An instrument for cutting thin sections of materials for microscopical examination.

MICROTURBIDIMETER—A device for comparing the relative and specific turbidities of fluids (O. E. Conklin, *J.C.S.*, 1925, Abs. II., 708).

MIL—The 1,000th part of a litre.

MILDEW—A general name applied to certain fungi, some of which form white patches on damp articles, plants, and foods. (See Fungi.)

MILK—The sole natural food of all the mammalia for some time after birth. There are variations in the quantities and composition of cows' milk due to differences in breed, age, feeding, and other factors. (See J. F. Tocher, *Analyst*, 1926, **51**, 146 and 606.) English cows give from 700 to 1,000 gallons milk during one lactation period. It contains on average 87·35 per cent. water, 3·75 per cent. fat, protein, milk-sugar, and certain salts, the relative proportions varying with the species. Cow's milk has a sp. gr. of from 1·029 to 1·034 at 15·5° C., contains about 14 per cent. of solids, of which about 4 per cent. is fat, 3·8 per cent. casein, 4·5 per cent. lactose, and gives about 0·7 per cent. of ash. The ash of normal milk has been given by Fleischman as follows:

K_2O (partly as Chloride)	24·5 per cent.	Fe_2O_3	0·3 per cent.
Na_2O (partly as Chloride)	11·0 ,,	P_2O_5	26·5 ,,
CaO	22·5 ,,	SO_3	1·0 ,,
MgO	2·6 ,,	Cl	15·6 ,,

N.B. by Author.—Deduct oxygen equivalent to the chlorine, and the total becomes 100·5.

As sold in this country, it is required to contain not less than 3 per cent. fats and 8·5 per cent. other solids. The freezing-point of ordinary milk lies on average about −0·54° C., and some use is made of this fact in determining its possible adulteration with water (see Elsdon and Stubbs, *Analyst*, 1930, **55**, 423), and as a means of examining the osmotic pressures of various biological fluids (see Elsdon and Stubbs, *J.S.C.I.*, 1031, **50**, 135 T). In souring, the milk-sugar is converted into lactic acid. (See Lactic Acid.)

The so-called "condensed milk" is made by evaporating off a quantity of its water—to about one-quarter of its original bulk—sugar being generally added at the same time. It keeps well, but as it is generally made from skimmed milk it is not so nourishing as fresh milk. Its

MILK (*Continued*)—

thickening upon storage in tins, stated sometimes to be due to bacterial action, really results from chemical and physical changes. (See *Condensed Milk*, by A. Miyawaki (Chapman and Hall, Ltd.).)

Pure dry milk is soluble when carefully prepared, and can be stored for months without loss of physiological value, and if the fat be first removed, the dry skim milk will keep indefinitely in tins, but is liable to deteriorate through growth of micro-organisms if it contains more than 6 per cent. water. As neutral refined cocoa-nut fat can also be kept for a long time without rancidity, these two materials can be emulsified into a milk, thus providing wholesome food where fresh milk is not available. Reconstituted cream is also now commercially produced by the emulsification of milk-powder, butter, and pure water.

The so-called pasteurization of milk is practised in order to partially sterilize it, and thus ensure, to some extent, the destruction of disease-producing organisms. No milk can be sold as "pasteurized" unless it has been maintained at between 145° F. (63° C.) and 150° F. (65·5° C.) for not less than thirty minutes; it must not be heated more than once, and after pasteurization it must not contain at any time more than 30,000 bacteria per c.c. It is said that this treatment destroys some of the minor essential nourishing factors, but the matter remains undecided. It has also been recently alleged that milk can be sterilized by certain sound waves.

Drum-dried whey is suitable as cattle food, while whey concentrated *in vacuo* at 60° C. or less and in the presence of chalk gives lactose of good quality upon crystallization. (See Lactose.)

Goat's milk (Egyptian) is stated to contain from 10·65 to 16·55 per cent. total solids (or mean 12·54 per cent.); fat from 2·45 to 7·35 per cent. (or mean 4·04 per cent.); and the butter churned from it to have a sap. v. of from 212 to 244 and i.v. of 20·7 to 29 (Hübl).

Jerome Alexander (*Chem. and Ind.*, 1924, **43**, 1256) has given the average composition of various milks as follows:

Kind.	Casein.	Lactalbumin.	Fat.	Lactose.
Cow	3·02	0·53	3·64	4·88
Woman	1·03	1·26	3·78	6·21
Goat	3·20	1·09	4·78	4·46
Ewe	4·97	1·55	6·86	4·91
Mare	1·24	0·75	1·21	5·67
Ass	0·67	1·55	1·64	5·99

References: "Variations in the Composition of Milk," by J. F. Tocher (H.M. Stationery Office); articles on Milk Powder (*Ind. Chem.*, 1927, iii., 494), and by Lampitt and Bushill (*J.S.C.I.*, 1931, **50**, 45 T, and *Analyst*, 1931, **56**, 778); "Some Problems connected with Milk," by C. J. H. Stock (*Analyst*, 1930, **55**, 535); "Examination of Milk for Tubercle Bacilli," by D. R. Wood (*Ibid.*, p. 544); "Fat in Spray-dried

MILK (*Continued*)—

Milk Powder," by Lampitt and Bushill (*J.S.C.I.*, 1931, **50,** 45 T); "Composition of Vixen Milk," by Young and Grant (*Analyst*, 1932, **57,** 49); "The Milk Industry," by J. Golding (*Chem. and Ind.*, 1932, **51,** 86); "Milk Pasteurization," by H. Raistrick (*Ibid.*, p. 88); *Condensed Milk*, by A. Miyawaki (Chapman and Hall, Ltd.); *Dairy Chemistry*, by H. D. Richmond (C. Griffin and Co., Ltd.); *A Textbook of Dairy Chemistry*, by E. R. Ling (Chapman and Hall, Ltd.); and *Dairy Bacteriology*, by B. S. Hammer (Chapman and Hall, Ltd.).

MILK-SUGAR—See Lactose.

MILLBOARD—A material of various thickness, prepared from paper of various qualities and used for binding and making boxes (cartons).

MILLERITE—Mineral nickel sulphide (NiS), of crystal system, No. 3, and sp. gr. 4·5 to 5·5, occurring at Lancaster in Pennsylvania.

MILLIGRAM—See Weights and Measures.

MILLON'S TEST, for albuminoids in suspected tissues, consists in moistening with a solution of 2 parts mercury dissolved in 4 of nitric acid of sp. gr. 1·40, and gently warming, when an intense red colour is produced if albuminoid matter be present; this colour is not destroyed by boiling with water or exposure to the air.

MILLS—See Grinding and Plauson's Colloid Mill.

"MILTON"—A disinfectant fluid containing sodium hypochlorite.

MIMOSA BARK—The produce of the *Acacia mimosa*, containing an astringent principle used in tanning, and resembling cutch in character and composition. (See Catechu.)

MINERAL ACIDS—A general name given to all acids other than those of organic character.

MINERAL BLACK—Carbonaceous deposits of carbonaceous shale, culm, coal, or slate prepared by grinding and levigation; for use in preparing black pigments. (See H. M. Langton, *Ind. Chem.*, 1928, iv., 311.)

MINERAL OILS—See Lubrication (p. 550) and Petroleum.

MINERAL RUBBER (**Gilsonite, Elaterite, Grahamite**)—See Gilsonite.

"MINERAL WOOL"—See Slag Wool.

MINERALOGY—The study of minerals and rocks: their composition, physical characters, crystalline forms, and geological relations. (See *Dana's Manual of Mineralogy*, by W. E. Ford (Chapman and Hall, Ltd.), and *Mineralogy*, etc., by H. A. Miers (Macmillan and Co.).)

MINERALS—Rocks and other inorganic materials found naturally. The output of minerals in the United Kingdom is given in table form in the Annual Reports of the Secretary for Mines, and the Annual Reports of H.M. Chief Inspector (H.M. Stationery Office). (See W. Cullen on "The Mineral Resources of the Empire" (*J. Inst. Chem.*, 1932, Part I., p. 37), and Ores.)

MINIUM (**Red Lead**)—See Lead Compounds, p. 527.

"**MINOFOR METAL**"—An alloy of 68·5 parts tin, 18·2 antimony, 10 zinc, and 3·3 copper, harder than Britannia metal; used for making forks, spoons, coffee and tea-pots, etc.

MIRBANE (**OIL or ESSENCE OF**)—See Nitro-benzene.

"**MISCH METAL**"—A mixture of cerium and other metals obtained from monazite sands; used in making ferro-cerium, etc. (See Pyrophoric Alloys.)

MISCIBILITY—Capability of admixture to a state of perfection. For example, vinegar can be admixed with water in all proportions, and oil of turpentine is miscible with spirits of wine. "Two substances with nearly identical internal pressures form perfect solutions; substances differing moderately show deviations roughly corresponding to the internal pressure difference; substances far apart in the series are commonly incompletely miscible" (J. A. V. Butler, *Chem. and Ind.*, 1925, **44**, 577). Miscibility is a property of gases also; oxygen gas can be mixed with hydrogen, for example, but solid bodies are not miscible in the same chemical sense. (See Mixtures and Diffusion.)

MISCOMETER—An apparatus for obtaining a composite sample of any two (or more) miscible liquids (J. Houston, *Analyst*, 1926, **51**, 453). An improved type is described by him (*Analyst*, 1929, **54**, 30).

MISPICKEL—Arsenical pyrites ($FeS_2 + FeAs_2$); crystal system, No. 4, and sp. gr. 5·7 to 6·3. (See Arsenic.)

MISTS—Arising from chemical reactions. (See H. Remy and H. Finnern (*B.C.A.*, 1927, A, 107); H. Remy (*B.C.A.*, 1929, B, 154); Wigand and Frankenberg (*B.C.A.*, 1930, A, 540); and Aldis and Philip (*J.C.S.*, 1930, p. 1103).)

MIXERS—Among other contrivances for mechanical stirring, an easily improvised one is described by C. O. Harvey (*Chem. and Ind.*, 1925, **44**, 815). (See *Agitating, Stirring, and Kneading Machinery*, by H. Seymour (Ernest Benn, Ltd., London); *Mechanical Mixing Machinery*, by L. Carpenter (E. Benn, Ltd., London); Grinding and Plauson's Colloid Mill.

MIXTURES—Mechanical mixtures as distinct from chemical compounds. (See Chemical Compounds (p. 169) and Diffusion.)

MOISTURE and CHEMICAL CHANGES—See Chemical Interactions, Heat (p. 436), Oxygen (p. 956), and Water (p. 970).

MOL—Gramme-molecule or molecular weight in grammes.

"**MOLASOCARB**"—A decolourant black made by decomposing molasses with lime, burning the mixture, and subsequently washing the char with chemicals to remove the lime and other salts.

MOLASSES (**Treacle**)—Uncrystallizable drainings from sugar, used to some extent for making glycerol. It contains generally about 50 per cent. invert sugar, potassium and other salts, the Java molasses having

MOLASSES (*Continued*)—

a much higher invert sugar content than beet molasses, which, however, contains a higher proportion of various salts. It is used as food, also variously for sweetening purposes, the manufacture of industrial alcohol, and the manufacture of rum (by fermentation and subsequent distillation of the fermented product). A low-grade cane molasses is known as "blackstrap," and from this West Indian material industrial alcohol is manufactured in Montreal by fermentation with a specially prepared yeast. The molasses has a composition as follows: invert sugar, 16 to 18 per cent.; sucrose, 36 to 38 per cent.; water, 20 to 22 per cent.; salts and carbohydrates, 22 to 28 per cent. The alcohol thus produced contains 95·63 per cent., and about $\frac{1}{2}$ of 1 per cent. of the alcohol produced is obtained as fusel oil (used for making amyl acetate) consisting of 8 per cent. ethyl alcohol, 12 per cent. normal propyl alcohol, 42 per cent. iso-butyl alcohol, and 38 per cent. iso-amyl alcohol. A description by E. C. Freeland of the manufacture of power alcohol and ether from cane molasses is given in *C.T.J.*, 1925, **77**, 8.

A certain amount of potassium carbonate is recoverable from the aqueous residue of beet-sugar molasses after fermentation and distillation of the resulting alcohol by carbonization and calcination.

Results of the action of a number of active carbons on the colouring matters of beet molasses is given in a paper by M. Garing and A. Regè (*B.C.A.*, 1929, B, 411).

Molasses residues in association with other materials have been advocated for use in making binders for anthracite coal briquettes. For feeding cattle, cane molasses is much preferable to the beet product, which contains aspartic acid and betaïne and possesses an unpleasant taste and smell. (See Glycerol, Sugar, and Vinasse.)

MOLECULES and MOLECULAR WEIGHTS—The term molecules in a chemical sense means the smallest imaginable quantities of substances capable of existing in the *free* (uncombined) state, as contrasted with atoms, which are constituents of molecules and the smallest chemical entities which can participate in chemical change. This view is now modified by the hypothesis that electrons can participate in chemical changes to a certain extent, but that does not affect the larger consideration. (See Atoms.) A molecule of sodium chloride (NaCl) (common salt) is a combination of an atom of the metal sodium (Na) with one atom of the gas chlorine (Cl):

$$\mathrm{Na} + \mathrm{Cl} = \mathrm{NaCl},$$

and as the atomic weight of sodium is 23 and that of chlorine is 35·5, it follows that the molecular weight of the compound is 58·5. Again, in the production of water (H_2O), 2 atoms of hydrogen (H) combine with 1 atom of oxygen (O) to form a molecule of water (H_2O):

$$\mathrm{H_2} + \mathrm{O} = \mathrm{H_2O},$$

and when water is decomposed by electrolysis, its molecule yields 2 volumes of hydrogen gas and 1 volume of oxygen gas at the same temperature and pressure.

MOLECULES AND MOLECULAR WEIGHTS (*Continued*)—

According to Avogadro's law (based on the kinetic theory of gases), equal volumes of gases, at the same temperature and pressure, contain the same number of molecules. If, then, equal given volumes of hydrogen and oxygen contain severally 1 molecule, it follows that as oxygen is known to be 16 times heavier than hydrogen, which has an atomic weight of 1, and as the molecule of hydrogen consists of 2 atoms, the molecular weight of oxygen must be $16 \times 2 = 32$. (See Satyendra Ray (*Chem. and Ind.*, 1928, **47,** 931) and F. L. Teed on the Kinetic Theory (p. 393).)

To take another instance, hydrochloric acid is a combination of 1 atom hydrogen gas with 1 atom of chlorine: $H + Cl = HCl$, and the respective weights of equal volumes of hydrogen and hydrochloric acid gases are 1 and 18·25. As the weight of hydrogen contained in a molecule of hydrochloric acid is only one-half that of the same element contained in an equal measure or volume of hydrogen, and as there is only 1 atom of hydrogen in the molecule HCl, it necessarily follows that the molecule of hydrogen consists of 2 atoms, and that the molecule of HCl must weigh 36·5, made up of 1 atom of H weighing 1 and 1 atom of chlorine weighing 35·5. The molecular weight of chlorine is therefore 71.

The relative weights of equal volumes of gases at the same temperature and pressure are known as their vapour densities, and it will be seen from the table on p. 589 that these are practically one-half of the numbers representing their molecular weights.

In other words, the atomic weights of gases are, with some exceptions, half the weights of the volumes of them respectively, equal to the volume of a molecule of hydrogen gas at the same temperature and pressure.

In those instances where the vapour densities are identical with the atomic weights, the molecules of the elements consist of 2 atoms, while the molecules of sodium, potassium, zinc, and mercury consist of 1 atom, and therefore their atomic and molecular weights are identical. Phosphorus and arsenic contain 4 atoms to each molecule, or in other words, the smallest weight of these substances which can take part in any chemical change is a fourth of their molecular weight or one-half of their vapour densities. (See Vapour Densities.)

The molecular weights of organic compounds are ascertained by determining the composition of their several combinations, as the mere analysis of them only gives the relative proportions of their ingredients. For example, the analysis of acetic acid shows that it contains 40 per cent. carbon, 6·6 per cent. hydrogen, and 53·4 per cent. oxygen, and if these percentages are divided by the atomic weights of the several constituent elements it will be found that their relative proportions are 3·3, 6·6, and 3·3, so that the formula might be either CH_2O, $C_2H_4O_2$, or $C_3H_6O_3$, etc. The analysis, however, of silver acetate shows that 1 atom of hydrogen is replaced by 1 of silver, so that the formula of this salt is $C_2H_3AgO_2$ (or $Ag,C_2H_3O_2$), and that of acetic acid $C_2H_4O_2$. (See Organic Analyses.)

As regards volatile organic substances, much assistance is rendered

MOLECULES AND MOLECULAR WEIGHTS (*Continued*)—
by ascertaining the densities of their vapours, as every molecule occupies a volume twice as large as that of an atom of hydrogen.

There are a number of other contributory methods too technical to be described in this volume, but which may be lightly referred to here.

The "cryoscopic" method depends upon the ascertained fact that in certain chemically allied cases the freezing-points of solutions are depressed proportionately to the number of molecules of the substances dissolved in equal volumes of the same solvents. The "boiling-point" method depends, on the other hand, upon the consideration that the boiling-points are raised from the same cause. "Rast's camphor method" depends upon the use of an electrically heated melting-point apparatus. (See F. A. Mason, *Chem. and Ind.*, 1925, **44,** 577, and *Chem. and Ind.*, 1926, **45,** 199.)

Various methods of investigation appear to show that a gramme-molecular weight of a substance contains about $6{\cdot}0 \times 10^{23}$ individual molecules, the most accurate value ascertained by determining the charge of the electron being $6{\cdot}062 \times 10^{23}$ (Millikan). (See *Chem. and Ind.*, 1926, **45,** 873; review of book by P. Lecomte du Noüy, *Ibid.*, p. 887; and *Molecular Spectra and Molecular Structure* (Faraday Society, London).)

"Molecular Association" was the subject of Baker's Presidential address to the Chem. Soc. on March 24, 1927. (See *J.C.S.*, 1927, p. 949.)

Name of Element.	Atomic Symbol.	Atomic Weight.	Molecular Weight.	Molecular Symbol.	Vapour Density.
Hydrogen	H	1	2	H_2	1
Nitrogen	N	14	28	N_2	14
Oxygen	O	16	32	O_2	16
Ozone	O	16	48	O_3	24
Fluorine	F	19	38	F_2	19
Sodium	Na	23	23	Na	11·5
Phosphorus	P	31	124	P_4	62
Potassium	K	39	39	K	19·5
Arsenic	As	75	300	As_4	150
Bromine	Br	80	160	Br_2	80
Iodine	I	127	254	I_2	127
Mercury	Hg	200	200	Hg	100

MOLYBDATES—Compounds formed by the action of bases (such as the alkalies) on molybdenum trioxide; sodium dimolybdate is $Na_2Mo_2O_7$.

MOLYBDENITE (MoS_2); crystal system, No. 3, and sp. gr. about 4·5.

MOLYBDENUM (Mo) **and its Compounds**—Atomic weight, 96; sp. gr., 10; and m.p., 2,550° C. According to F. W. Aston, it has 7 isotopes (*Nature*, 1930, **126,** 348). Molybdenum is contained in the mineral *molybdenite*, which is a sulphide (MoS_2) resembling graphite in appear-

MOLYBDENUM (*Continued*)—

ance found in Australia, the U.S.A., Bohemia, Canada, and Sweden. It also occurs in *molybdenum ochre* (an oxide, MoO_3); *wulfenite,* a double oxide of lead and molybdenum ($PbMoO_4$); and *molybdite* ($Fe_2O_3,3MoO_3,7\frac{1}{2}H_2O$), which often accompanies molybdenite.

Upon roasting the native sulphide in a current of air, the sulphur is burnt off as sulphur dioxide (SO_2), an oxide of molybdenum being left behind, and by mixing this with oil and charcoal and then strongly heating the mixture, the molybdenum is reduced to the metallic state. The metal is also prepared by alumino-thermic reduction of molybdic acid (H_2MoO_4) (a white powder slightly soluble in water), which can be readily prepared from the trioxide.

As prepared from low-grade ore for the direct addition to steel, calcium molybdate is of growing importance, and progress has been made in the electrolytic production of the metal from fused bauxite admixed with calcium molybdate, as also by the electrolysis of molybdenum-sodium chloride.

Calcium molybdate is a white, crystalline compound obtained by fusion of calcium oxide with a molybdenum ore, while normal barium, strontium, and lead molybdates can be obtained, according to V. G. Aranda, by fusion of chlorides of the metals with normal sodium molybdate. (See *B.C.A.*, 1929, A, 779.)

The metal is greyish-white, ductile, difficult to fuse, and in the form of wire has a tensile strength about half that of tungsten or steel wire. It is used as a blue pigment for pottery; also in place of tungsten to the extent of about 1 per cent. in making high-speed steel parts, such as crank-shafts and connecting-rods, and otherwise in metallurgy.

An alloy of 60 per cent. Mo, 10 Pt, 10 per cent. W, and 20 per cent. of a Cu-Ni alloy is said to be better for the manufacture of fountain-pen nibs than the usual Pt-Ir alloy, and the molybdenum strip also finds use in the manufacture of electrical apparatus.

When heated in the air to 600° C. molybdenum oxidizes into a yellow powder of composition MoO_3 (known as molybdic acid); other oxides (MoO, MoO_2, and Mo_2O_5), and several chlorides are known.

Ammonium molybdate [$(NH_4)_2MoO_4$], prepared by the action of concentrated ammonia on the trioxide, is a white crystalline substance, soluble in acids, used in analytical work and in the manufacture of pigments.

Ferro-molybdenum is produced directly from the sulphide in an electric furnace or by the thermite process from the calcined ore. (See "Molybdenum and its Compounds," by W. G. Cass (*Ind. Chem.*, 1929, v., 429); V. L. Eardley-Wilmot (*C.T.J.*, 1926, **78**, 91; *Ibid.*, 1927, **80**, 602); E. W. Engle (*B.C.A.*, 1927, B, 680); also Iron Alloys, p. 498.)

MONACETIN—The three acetic esters mona-, di-, and tri-acetins can be prepared from glycerol. (See Acetin and Triacetin.)

MONAD—See Valencies.

MONAMINES—See Amines.

MONARDA OIL—There are a number of oils so named, one of the most fragrant being distilled from *Monarda citriodora* (known in the U.S.A. as "lemon mint"); the yield is about 1 per cent., sp. gr. 0·947 to 0·965; carvacrol (isomeric with thymol) being contained therein to the extent of from 65 to 80 per cent. (Compare Horsemint Oil.)

"MONAX"—See Glass, p. 403.

MONAZITE SAND—A natural, crystalline phosphate of cerium and lanthanum, generally containing didymia and thorium compounds also, occurring in extensive sand deposits in West Borneo, Colorado, a certain part of Orissa (India), Carolina, the coast of Brazil, Tasmania, and Travancore (a native Indian state under British protection). These are freed from much of the associated lighter materials by sluicing with water and electro-magnetic separation, so that the purified product consists of from 85 to 90 per cent. real monazite, containing about 9 per cent. thoria and 60 per cent. of cerium oxides. These in turn are subsequently converted into nitrates, in which form they are used in the incandescent mantle trade. The West Borneo variety has a thorium content of over 9 per cent.; Brazilian monazite contains about 6 per cent. thorium oxide, the Travancore and Ceylon deposits about 9 per cent., and while some are reported to contain as much as 18 per cent., other varieties are devoid of it. The total rare earths minus thorium as obtained by the electrolysis of their mixed chlorides, in alloyed form with iron, constitutes the sparking metal familiar as pipe-lighters. The thorium monazite sands are used as a source of helium, yielding about 1 litre from 1 kg. of the sand by heating. (See Gas Mantles, Helium, Incandescence, and Thorium.)

"MOND" GAS—As originally made for generating combustible gas, its production was based upon the passage of air in regulated amount through a mass of red-hot coal contained in a so-called gas producer, thus yielding a gas containing about a third of its volume of carbon monoxide, the nitrogen from the air used, and some carbon dioxide. In recent modifications of the process using air and steam the nitrogen is recovered as ammonia. (See Producer Gas and Water Gas.)

"MONEL"—Proprietary alloys (prepared from a mixed ore at Sudbury, Ontario), one consisting of approximately 67 per cent. nickel, 28 per cent. copper, and 5 per cent manganese (or cobalt) and iron; sp. gr. 8·82, and m.p. 1,160° C. It resists the action of sea-water, steam, dilute acids, and alkaline solutions; is of low heat conductivity, great tensile strength, machines readily, and is used for making superheated steam fittings and parts of chemical plant used respectively under caustic alkaline conditions and for varnish making, etc. (For details of its preparation as now conducted and its properties, see N. C. Marples (*Chem. and Ind.*, 1931, **50**, 286); also M. G. Binek (*B.C.A.*, 1930, B, 772, and *C.T.J.*, 1931, **88**, 609).)

MONK'S HOOD—See Aconitine.

MONO (**Mon**)—Prefix meaning one—such as one content of a substance. (See Basicity and Valencies.)

MONOBASIC—See Basicity and Valencies.

MONO-CHLORBENZENE—See Chlorobenzenes.

MONO-CHLOROACETIC ACID (Cl,CH_2CO_2H)—A colourless, deliquescent, crystalline substance of caustic character, sp. gr. 1·4, m.p. 62·5° C., and b.p. 185° C., prepared by action of chlorine upon hot acetic acid in presence of acetic anhydride, phosphorus, or sulphur. It is soluble in water, alcohol, and ether, and is used as an important synthetic reagent; industrially in the sodamide method of manufacturing synthetic indigo, and finds use as a corn and wart remover.

MONO-ETHYL ANILINE ($C_2H_5.NH.C_5H_6$)—A colourless liquid intermediate, soluble in alcohol; sp. gr. 0·9631 and b.p. 206° C.

MONOVALENT—See Valencies.

"MONOX"—A mixture of silicon monoxide with the dioxide and silicon, made by reducing siliceous sand with silicon, carborundum, or coke in an electrical resistance or arc furnace. It is a yellowish-brown, opaque powder, silky to the touch, which decomposes water (hydrogen being evolved), and constitutes a good thermal and electric insulator, its thermal resistivity being 2,500 thermal ohms, so that it finds use as a calorifuge. It has also the property of thickening liquids, and when mixed with oil or water gives a paint of good covering power. (See *C.T.J.*, October 13, 1922.)

"MONSOL"—A proprietary coal-tar antiseptic.

MONTAN or **MONTANA WAX**—See Lignite and Waxes.

"MOOGROL"—A preparation of esters of acids of the chaulmoogric series, used for treatment of leprosy, etc. (See Chaulmoogra Oil.)

MOONSTONE—Transparent felspar or orthoclase.

MORDANTS—Chemical substances used for fixing colours in dyeing and calico-printing. (See Dyes and Lakes.)

MORIN ($C_{15}H_{10}O_7$)—One of the colouring matters of *Morus Tinctoria* (old fustic) related to the flavones, and recently synthesized by Robinson and Venkataraman (*J.C.S.*, 1929, p. 61). (See Fustic Extract.)

MORPHINE (**Morphia**)—See Opium and Heroin.

MORTAR—A mixture of 1 part (volume) burnt lime slaked with water to a thin cream and 3 parts (volumes) sharp sand, the hardening and setting of which (as when used for bricklaying) depend partly upon drying and partly upon absorption of carbon dioxide from the air by the lime, thus converting it into calcium carbonate:

$$CaH_2O_2 + CO_2 = CaCO_3 + H_2O.$$

This carbonating effect, however, does not play much part in the hardening of the mortar. If the sand be very finely ground, calcium silicate is gradually formed. It contains about 73·4 per cent. sand and 6·5 per cent. CaO. When a quick setting is required, a varying proportion of Portland or Roman cement (up to 50 per cent.) is incorporated, according to the nature of the intended application. (See

MORTAR (*Continued*)—

Smith and Crosthwaite on "Cement Mortars with Reference to their Compressive Strength," etc. (*B.C.A.*, 1925, B, 960); Cement, and Concrete.)

MORTARS—See Grinding.

MOSAIC GOLD (**Ormolu**)—A variety of brass, being an alloy of copper and zinc in equal parts. The name is also that of a pigment made of the golden-yellow-coloured stannic sulphide (SnS_2). (See Tin, p. 919.)

MOSELEY'S LAW—The nucleus of atoms is stated to contain all the positive charges and some of the negative charges, the number of electrons in the orbit of the miniature solar system as so hypothetically viewed, being equal to the net positive charge on the nucleus, which is Moseley's atomic number as determined by wave lengths; the heavier the elemental atom the shorter the wave length. It may be otherwise expressed as the difference between the ponderable positive particles and the non-ponderable negative particles of electricity included in the atomic weight. (See Atoms, Electrons, and Isotopes.)

MOSS AGATE—A variety of the mineral known as *chalcedony*.

"MOTALIN"—A German "non-pinking" benzol fuel containing 0·2 to 0·25 per cent. iron carbonyl, for use in internal combustion engines. (See "Motyl.")

MOTH PROOFERS—Para-dichlorobenzene has been reported upon favourably in the U.S.A., as also some preparations made from the cinchona alkaloids; naphthalene, kerosene, and camphor, among other substances, are commonly used. The "Eulan" preparations are referred to under that heading, and there are British products said to be superior to them. Sodium silicofluoride to which a proportion of alum is added is also used (the aluminium ions accelerating the process), the strong solution being applied by spray or short immersion. (See Minaeff and Wright (*Ind. Eng. Chem.*, 1929, **21**, 1187); also *Ind. Chem.*, 1927, iii., 504.)

MOTHER-LIQUOR—The residual liquor after the chief constituent has been removed from a solution as far as possible by deposition or crystallization. For example, codeine, being a more soluble substance than morphine, is left in the mother-liquor after the morphine has crystallized out, and bromine is recovered from the mother-liquor from the manufacture of potassium chloride. (See Bromine, Codeine and Opium.)

MOTHER OF PEARL (**Nacre**)—The brilliant, silvery, hard layer of oyster and other shells, consisting of a cellular skeleton of an albuminoid material named "conchyoline," secreted by the oyster (*Avicula macroptera* and other species), containing, according to a typical analysis, 66 per cent. calcium carbonate, water 31 per cent., and organic matter 2·5 per cent. It is extensively used for inlaying articles. (See P. B. Ganguly, *J.C.S.*, 1926, p. 1381; also Pearls.)

MOTOR ENGINE OILS—The standards of current descriptions are laid down by the B.E.S.A. (See Lubricants and Standard Specifications.)

MOTOR FUELS—Information on this subject is given under the headings of Alcohol, Benzene, Coal, Coke, Fuel, Motor Spirit, Petroleum, and "Synthol." (See also Rex Furness (*Ind. Chem.*, 1925, i., 475) and J. D. Smith (*Gas Journal,* July 1, 1931).)

MOTOR GREASE is prepared in a number of varieties, ordinary soap being used in many. One recipe is as follows: lubricating oil of sp. gr. 0·900 to 0·910, 80 parts, stearic acid 15 parts, and caustic soda 2 parts; part of the oil being melted with the stearic acid and mixed with the soda in 40 per cent. solution, the remainder of the oil being subsequently incorporated. Cheaper grades are compounded with lime soap. (See Greases and Lubricants.)

MOTOR SPIRIT (Petrol)—This consists of benzol or fractional distillates from crude petroleum or "cracked" petroleum products, with or without admixture with benzol, ranging in boiling-point from about 40° to 225° C. "Straight run petrol" is petrol distilled from natural crude oil. A motor spirit is also obtained by the carbonization of bituminous coals at from 600° to 1,200° C. to the extent of about 2·5 gallons per ton (in addition, of course, to the gas, coke, and other tar products). It is also reported that colza and some other vegetable oils yield a sort of petrol by the action of molten zinc chloride.

A suggested definition of motor spirit is "any hydrocarbon spirit (other than turpentine) consisting substantially of hydrocarbons boiling below 225° C.," while W. R. Ormandy has expressed the opinion that the value of motor fuel to-day must be based on its ability to withstand high compression, and not on its latent heat. The average final boiling-point of petrol No. 1 in this country is about 180° C., and that of aviation spirit 140° C.

Crude benzol motor spirit, unlike the refined article, shows a tendency to resinify on storage, in respect of which change tri-cresol acts to some extent as an inhibitive. The Benzol Research Committee found that phenols in suitable amount, for a time, entirely prevent resinification under storage conditions. In recent years in the refining of crude oil the so-called hypochlorite process has been adopted, in which motor spirit is washed with a 0·2 N. solution of calcium or sodium hypochlorite containing free alkali of from 0·5 to 1·0 grns. $NaHO$ per litre, by which means the malodorous sulphur compounds are oxidized into innocuous bodies soluble in water.

The composition of Pratt's No. 1 and Shell spirit No. 1 has been given (see *C.T.J.*, 1925, **76,** 135) as follows:

	Pratt's.	Shell.
Initial boiling-point	40° C.	42° C.
Over at 100° C.	48 per cent.	33 per cent.
Final boiling-point	193° C.	190° C.
Aromatic content (by aniline cloud test)	8·4 per cent.	22·9 per cent. (by weight).

MOTOR SPIRIT (*Continued*)—

The so-called "knocking" of motor fuel causes loss of power and sometimes mechanical damage. Some of the higher paraffins are bad offenders. It has been found that "knocking" or "pinking" (detonation of the explosive charge) can be stopped by adding traces (up to 1 part in 1,000) of certain organo-metallic compounds such as teraethyl lead ($PbEt_4$) to the fuel oil used in internal combustion engines. It has also been reported that if an uncorked bottle of di-ethyl selenide be held near the air inlet of a violently detonating engine, the "knocking" at once ceases. The tetra-ethyl lead preparation is now compounded with a volatile organic halogen (such as ethylene bromide) to prevent the deposition of lead on the sparking plugs, and the mixture is known as "ethyl fluid." Tetra-ethyl regulations concerning the manufacture and blending of the article made by the U.S. Surgeon-General's Committee will be found in the *Ind. Chem.*, 1926, ii., 257.

Tests made in Australia make it appear that the addition of from 15 to 20 per cent. absolute (anhydrous) alcohol to ordinary petrol makes an ideal fuel of anti-knock character, and that alcohol is twice as efficient as benzol in stopping "knocking." Iron-penta-carbonyl has also found commercial employment (see Motyl), but it is apt to leave a deposit of iron oxide on the sparking plugs, thus causing short-circuiting.

The subject has received attention at the hands of Graham Edgar (*J.S.C.I.*, 1928, **47,** 230 T); T. A. Boyd (*Chem. and Ind.*, 1929, **48,** 294); Berl and others (*B.C.A.*, 1929, B, 158); and Olims and Jeben (*Ibid.*, B, 159); while "Knock Ratings of Aromatic Hydrocarbons" is the subject of a paper by Howes and Nash (*J.S.C.I.*, 1930, **49,** 16 T, and 113 T). See also the final Report of the Departmental Committee on Ethyl Petrol (H.M. Stationery Office), in which the use of this agent is reported as unobjectionable, subject to certain regulations detailed therein.

"Gasin," "Motyl," and "Motalin" are German makes of anti-knock motor fuels.

It is stated that by adding a small percentage of ammonium oleate to petrol the compression ratio of an internal combustion engine can be raised from 5 to 1 to 7 to 1, and Professor Marks (Harvard) has stated that cerium oxide as a coating on the cylinder head of an engine of low efficiency and comparatively low speed improves the efficiency by about 20 per cent.

The better qualities of petrol can be used as solvents, and—in common with gasoline—for producing "air gas" for illuminating purposes and its other applications.

The manufacture of synthetic motor fuel is referred to under Synthol.

The quantity of motor spirit, including benzol, used in the British Isles was some few years ago estimated at approximately 500,000,000 gallons, while the U.S.A. output of petrol or naphtha in 1913 was then estimated at 1,100 million gallons, representing 12·5 per cent. of the crude oil produced.

(See "Cracking of Wood Tars" (Morrell and Eglof, *B.C.A.*, 1929, B, 583); "Cracking of Heavy Oils" (Dunstan and Pilkethley, *C.T.J.*,

MOTOR SPIRIT (*Continued*)—

1924, **75,** 451); "Formation of Gum in Motor Fuels," by Brunschwig and Jacqué (*B.C.A.*, 1931, B, 187); "Motor Benzol from Coal Gas," by E. L. Hall (*C.T.J.*, 1926, **78,** 631); "Dopes and Detonation," by L. Callener (*B.C.A.*, 1927, B, 272); "Knock Ratings of Certain Olefines," by F. H. Garner (with others) (*Chem. and Ind.*, 1932, **51,** 227); *Motor Benzole: its Production and Use,* by Hoffert and Claxton (National Benzole Association, Ltd., London); also Coal (p. 212), Cracking, Gasoline, "Motyl," Oils, Petroleum, Rape Seed, and Synthol.)

MOTTRAMITE—Mineral vanadate of lead and copper containing about 17 per cent. vanadium. (See Vanadium.)

"MOTYL"—A German preparation of iron carbonyl in benzol in concentrated form, used in preparation of liquid fuels for use in internal combustion engines. (See Iron Carbonyl, "Motalin," and Motor Spirit.)

MOULDS—See Fungi.

MOURA (**MOWRA**) **OIL**—A yellow, semi-liquid fat, soluble in ether, benzene, and carbon disulphide, extracted to the extent of about 60 per cent. from the seeds of *Bassia latifolia* (India), having an odour like that of cacao beans, and used in soap-making; sp. gr. 0·894 to 0·898, m.p. 23° to 29° C., sap v. about 190, and i.v. about 60.

MUCIC ACID ($C_6H_{10}O_8$)—An optically inactive, crystalline, dibasic acid, sparingly soluble in cold water, prepared by oxidation of dulcitol, lactose, gums, mucilage, etc.; m.p., 213° C. The process for making it from larch sawdust is based on treatment with a hydrolytic agent, and then oxidation of the resulting galactose solution ($C_6H_{12}O_6$) with nitric acid at 50° to 85° C., followed by evaporation and crystallization of the mucic acid.

By treating galactose with the nitric fumes from the arc process of nitrogen fixation, mucic acid can be made cheaper than tartaric acid or cream of tartar, for both of which it is a substitute for use in cooking. Apart from its employment as a baking powder, it finds use in the mineral-water trade and in the dyeing and textile industries.

MUCILAGE—Gum prepared from certain seeds and roots which contain large quantities of a substance which swells up with water into a mucilage. Such mucilages can be prepared from gum acacia, tragacanth, linseed, and quince seed, but the term now is often applied to any kind of adhesive paste. (See Adhesives and Gum Arabic.)

MUCINS—A class of glyco-proteins (gluco-proteins), insoluble in water, which occur in some secretions, and yield a class of albumins and carbohydrate upon hydrolysis.

MULLITE—See Sillimanite.

"MULSOID"—A cleansing colloid compound.

"MUMETAL"—An alloy of nickel and iron of high electrical permeability. (See "Permalloy.")

MUNDIC—A Cornish term for iron pyrites.

MUNTZ METAL—See Alloys and Copper.

MUREXIDE (Ammonium Purpurate) [$(NH_4)C_8H_4N_5O_6$]—A purple colouring matter produced from uric acid by moistening with dilute nitric acid and gently warming with ammonia. Its production is a test for the presence of uric acid.

MURIATIC ACID—An old name for hydrochloric acid.

MURUMURU BUTTER—A fat from the seeds of the fruit of *Astrocaryum murumuru* (a kind of South American palm-tree), amounting to about 40 to 42 per cent.; sp. gr. at 15° C. 0·918, m.p. 34° to 35° C., sap. v. 240 to 241·5, Reichert-Meissl value 2·8 to 3·14, and Hanus i.v. 11·2 to 11·5. It contains stearic and possibly arachidic acid, also caprylic and capric acids. Later details of its composition and properties are given by M. Garaiva (*B.C.A.*, 1929, B, 986).

MUSCARINE (represented as $C_5H_{15}NO_3$, but the formula of which has not yet been definitely determined) is a very poisonous base contained in toadstool (*Agaricus muscaria*). Muscarine chloride has been given the formula $(CH_3)NCl.CH_2.CH(OH)_2HCl$ or $C_3H_9NO_2Cl_2$. (See Choline.)

MUSCOVITE or "POTASH MICA" ($K_2O,3Al_2O_3,6SiO_2,2H_2O$); crystal system, No. 5, and sp. gr. 2·7 to 3·0. (See Mica.)

MUSK—An aromatic, resinous substance used in perfumery, medicine, etc., obtained from an internal part—the preputial follicles—of the musk deer (*Moschus moschiferus*) inhabiting parts of N. Asia (Tonquin and Thibet). The odour is due to a ketone named muskine or muscone ($C_{16}H_{30}O$), now made synthetically in Switzerland, and marketed under the trade name of "Exaltone." (See *C.T.J.*, 1926, **79**, 708; and F. Grove Palmer (*Chem. and Ind.*, 1931, **50**, 845).) The oil is also stated to contain valeric acid.

MUSK (Artificial)—Nitro-aromatic compounds, chemically distinct from and enormously more powerful in odour than the natural musk, which, however, is of more delicate fragrance. The xylene musk (musk xylol) is a crystalline body of m.p. 113° C., being the tri-nitro-tertiary-butyl-*m*-xylene, and is prepared from meta-xylene by a condensation process, followed by nitration. The tertiary compound before nitration is represented as $C_6H_3(CH_3)_2.C(CH_3)_3$, and the nitrated body as

$$C_6(CH_3)_2(C_4H_9)(NO_2)_3.$$

Musk ketone is rather weaker, of m.p. 136° C., and is said to be the di-nitro derivative of butyl-xylol-methyl ketone of the composition $CH_3.CO.C_6(C_4H_9)(CH_3)_2(NO)_2$, while the corresponding compound made from butyl toluene is $CH_3.CO.(C_6H)(C_4H_9)(CH_3)(NO_2)_2$ of m.p. 131° C. Probably many commercial preparations contain both bodies. (See Parry's *Cyclopædia of Perfumery*, pp. 483-484; and *C.T.J.*, 1926, **78**, 349 and 607, which latter articles give details of the manufacture of the cheaper and better grades respectively.)

"MUSKONE" (Muscone, Muskine)—See Musk.

MUST—The juice of crushed grapes as expressed for wine-making (before fermentation).

MUSTARD—A condiment made from the seeds of black and white mustard (*Sinapis nigra* and *S. alba*, N.O. Cruciferæ) by grinding and sifting. Both yield oil by pressure to the extent of 25 per cent. in the case of the white seed and about 30 per cent. in that of the black variety. This oil, which is entirely liberated when mustard flour is macerated at 70° C., solidifies at $-17°$ C., has a sap. v. of 174, sp. gr. 0·014 to 1·103, i.v. 92 to 123, and a ref. ind. 1·467 to 1·475 at 15·5° C. It contains some allyl compounds and is used in medicine. In addition to this fixed non-drying oil, the seeds of the black variety, after pressure, contain a glucoside named sinigrin, which by the action of an enzyme named myrosin yields, upon moistening with water and standing, a very pungent volatile oil of sp. gr. 1·02 to 1·03 containing allyl iso-sulphocyanate, together with glucose:

$$C_{10}H_{16}O_9NS_2K + H_2O = C_6H_{12}O_6 + C_3H_5.NCS + KHSO_4.$$

Sinigrin can be obtained in crystalline form, and melts at 79° C. The white mustard seeds contain an alkaloidal body named sinapine ($C_{16}H_{25}O_6N$), which similarly yields acrinyl cyanate (C_7H_7SCNO) by the action of the same enzyme, and is stated to yield choline upon hydrolysis. The action of mustard plaster is due to the vesicating action of these hydrolytic products. (See N. Beliaier (*B.C.A.*, 1931, B, 595); and Notes on its Manufacture, by K. B. Quinan (*Ind. Chem.*, 1931, vii., 474, 491).)

"MUSTARD GAS" (**Yperite**)—See Gassing.

"MUTOCHROME"—A battery of lenses forming a camera and projector for photography of a textile pattern or design, arranged so that a coloured image of one element thereof is given by each lens, and each of these is photographed on to the same plate.

MYCOLOGY—See Fungi.

MYDRIATIC—The property of causing dilatation of the eye pupil exhibited by a number of substances, including hyoscyamine and homatropine.

MYELINE—A crystalline phosphatide contained in brain matter, soluble in hot alcohol. (See Brain Matter.)

MYOTIC—The property of causing contraction of the eye pupil exhibited by a number of substances, including eserine. (See Calabar Bean.)

MYRCIA OIL—See Bay Oil.

MYRICA WAX—See Waxes (Bayberry).

MYRICIN—See Waxes (Beeswax).

MYRISTIC ACID ($C_{14}H_{28}O_2$)—A crystalline fatty acid of the normal series, m.p. 54° C., present in oil of iris and nutmeg-butter, obtained from *Myristica moschata*, N.O. Myristicaceæ; soluble in hot alcohol.

MYRISTICIN—See Nutmeg Oils.

MYROBALANS (**Myrabolans**)—The dried fruit (nuts) of the Chinese and Indian trees *Terminalia belerica*, *T. chebula*, *T. citrina*, and allied species of the N.O. Combretaceæ, containing from 25 to 50 per cent. tannin, and used, like galls, in the tanning industry. The emblic myrobalan (*Phyllanthus embilica*, of the N.O. Euphorbiaceæ) is very

MYROBALANS (*Continued*)—
liable to attack by fungi (*Penicillium*) in the presence of moisture, and consequent loss of tannin content.

They contain a large proportion of gums, and, in the form of fine powder or extract, are used for dyeing black cotton goods; also in the indigo-dyeing industry for removing surplus dye from the fabrics, and for preparing ordinary and copying inks. For particulars concerning the tan and non-tans of S. Indian myrobalans see Choudary and Nayudu (*B.C.A.*, 1930, B, 206).

MYRRH.—See Gums.

MYRTLE OIL—Distilled from the leaves of *Myrtus communis* (a genus of Myrtaceæ); light yellow or greenish-yellow, and of agreeable odour, containing cineol, dextropinene, and dipentene, but varying in properties with the countries of origin. It is soluble in alcohol and ether, has a sp. gr. 0·896 to 0·92, opt. rot. +10° to +30°, and used in medicine and perfumery. In a later report it is stated to contain about 21 per cent. of *d*-pinene and some compound of the formula $C_{10}H_{18}O$, together with about 25 per cent. free alcohols, etc. (See L. Vodret, *B.C.A.*, 1928, B, 913.)

MYRTLE or LAUREL WAX—See Waxes.

NAAL OIL—Obtained from Naal grass (*Cymbopogon nervatus* Chiov), which grows in the Sudan, the yield being from 0·8 to 1·5 per cent. by weight of the dried grass. It is light yellow, with an odour like that of ginger grass (the variety of *Cymbopogon martini*), and is known in India as "Sofia" oil. It has a sp. gr. of about 0·954, ref. ind. 1·495, is soluble in alcohol, and contains *l*-limonene and perillic alcohol.

NAPHTHA—A more or less general term given to oily bodies produced from petroleum and by the distillation of cannel coal and bituminous shale, containing paraffin in solution of mixed hydrocarbons; used for illuminating purposes, in varnish-making, also as solvents for rubber, etc. One such liquid is found associated with deposits of bitumen and asphalt in many places, and is distilled therefrom.

Heavy Naphtha, as prepared from coal tar, is dark-coloured, has a sp. gr. of 0·925 to 0·950, and flash-point about 78·3° C. It is used as a solvent and in paint-making; also for making coumarone resins.

Water-White Naphtha (**"Hi-flash"**) has a sp. gr. of 0·870 to 0·880, b.p. between 165° and 186° C., a flash-point not below 37·8° C., and is largely used as a solvent.

Solvent Naphtha 90/160 and 90/190 are mixtures of benzol, toluol, xylol, etc., derived from coal-tar distillation. (See Benzene, Coal, and Petroleum.)

Wood Naphtha (wood spirit so-called) is of alcoholic character and is marketed in the forms of "solvent" and "miscible 60° per cent." (See Alcohols, p. 20.)

NAPHTHALENE ($C_{10}H_8$)—A white, solid hydrocarbon obtained from coal tar, and chiefly contained in the fraction that distils between 180° and 200° C., from which it crystallizes out on cooling, and is subse-

NAPHTHALENE (*Continued*)—

quently purified by treatment with small quantities of strong sulphuric acid, followed by sublimation. (See *C.T.J.*, 1927, **80**, 389.) About 40,000 tons are annually produced in this country.

Pure naphthalene, which was synthesized by the late W. H. Perkin, crystallizes in white glistening plates, m.p. 80° C., b.p. 218° C., sp. gr. 1·007, and is readily soluble in hot alcohol, benzol, and ether. It has a peculiar tarry odour, and is prepared commercially in the forms of crystals, flakes, balls, powders, and sticks. It is largely used in the manufacture of phthalic acid, naphthylamines, naphthols, naphthalene-sulphonic acids and other intermediates, "tetralin" and "dekalin" (by a process of hydrogenation); also for carburating illuminating coal gas. It possesses antiseptic properties; is carried in the forms of balls and sticks by natives of India and the Far East as a fever preventative; also employed therapeutically as a soil fumigant, and has been advocated as a motor fuel in a state of solution in benzol.

Naphthalene-sulphonic Acid ($C_{10}H_7SO_3H.H_2O$)—A crystalline deliquescent intermediate of m.p. about 85° C., soluble in water, alcohol, and ether, prepared by the interaction of naphthalene and sulphuric acid. A number of isomers are known.

There are two naphthalene di-sulphonic acids ($C_{10}H_6(SO_3H)_2$) also used as intermediates. When naphthalene is sulphonated in the vapour phase much less acid is required, and there is a better production than by the use of liquid acid, the transformation into useless isomeric acids being largely prevented.

Mononitro-Naphthalene ($C_{10}H_7NO_2$)—Prepared by the action of mixed nitric and sulphuric acids on naphthalene, is a yellow crystalline salt, m.p. 60° C., soluble in alcohol and ether, and used in the preparation of explosives and dyes.

Dinitro-Naphthalene ($C_{10}H_6(NO_2)_2$) is used in the preparation of explosives and "alizarin black."

NAPHTHENES—Saturated cyclic hydrocarbons (C_nH_{2n}). (See Petroleum.)

NAPHTHIONIC ACID (**Acid Naphthylamine-sulphonic**)—A white crystalline intermediate ($C_{10}H_6(NH_2)SO_3H$), obtained by the sulphonation of *a*-naphthylamine, soluble in alcohol and ether, and used in the preparation of azo-dyes.

NAPHTHOL (**Alpha**) ($C_{10}H_7OH$) is a colourless, crystalline substance used in making dyestuffs, which melts at 94·2° C., and is soluble in benzol, alcohol, and ether, but only slightly soluble in water. It is prepared by fusing alpha-naphthalene sulphonate and caustic soda, and decomposing subsequently with hydrochloric acid and distilling.

NAPHTHOL (**Beta**) ($C_{10}H_7OH$) is a white, lustrous substance of phenolic odour contained in coal tar, m.p. 121·6° C., b.p. 282° C.; soluble in benzol, alcohol, ether, and chloroform, and slightly soluble in water; made by fusing beta-naphthalene sulphonate with caustic soda, and subsequent distillation *in vacuo*. It is used in making dyestuffs and as an intestinal antiseptic in diarrhœa of children.

NAPHTHOLS—Phenols of the naphthalenes.

NAPHTHYL—The radical $C_{10}H_7$—.

NAPHTHYLAMINES used as "intermediates" include *a*-naphthylamine ($C_{10}H_7.NH_2$), a colourless, crystalline compound of disagreeable odour, m.p. 50° C., b.p. 300° C., obtainable by reduction of *a*-nitronaphthalene ($C_{10}H_7.NO_2$), and readily soluble in alcohol; and *b*-naphthylamine, a crystalline odourless compound, m.p. 112° C. and b.p. 294° C., obtainable from *b*-naphthol by action of ammonium hydroxide and sulphite. (See Naphthalene.)

"**NAPLES YELLOW**"—A pigment made of lead antimoniate, used in the oil, paint, and ceramic industries. (See Lead Compounds, p. 528.)

NARCEINE—See Opium.

NARCOTICS—Anæsthetic and hypnotic preparations which induce sleep or insensibility by action on the nerve centres, and alleviate pain, such as chloroform, opium, sulphonal, veronal, etc. The *C. and D.* of November 8, 1930, gives a summary of Dr. Anselmino's report to the League of Nations respecting the manufacture of these drugs, together with a table of productions.

NARCOTINE—See Opium.

"**NARCYLENE**"—An anæsthetic, said to consist of purified acetylene and oxygen flavoured with some pine oil.

"**NARKI**" **METAL**—A proprietary silicon cast-iron alloy containing 13 to 14 per cent. silicon, chiefly used in making plant for resisting nitric, sulphuric, and phosphoric acids, but not suitable for sulphuric acid below 112° T. Its tensile strength is stated at one-eighth of cast iron.

NASCENT—A term used to indicate the state of chemical substances at the moment of their generation or liberation from combination, when they are often more active in their properties than ordinarily—due possibly to being at that stage in an atomic rather than molecular form. It has been shown that the chemical affinity of such gases as hydrogen, oxygen, nitrogen, and carbon monoxide is increased by bringing them in contact with solutions in very minute bubbles, as obtained, for example, by forcing these gases through cartridges of paper. Hydrogen thus prepared reduces mercuric chloride to calomel, potassium nitrate to nitrite, and carbon dioxide to formaldehyde. With oxygen gas, ammonia is oxidized to nitrous acid and methyl alcohol to formaldehyde; while with nitrogen and hydrogen an indication of the production of ammonia is observed. Further examination of bodies in the nascent state may throw some light upon the nature of the so-called isotopes. (See also Energy, Hydrogen (p. 459), and Nitrogen (p. 611).)

"**NATALITE,**" a motor fuel made to contain either 50 per cent. or 90 per cent. by weight of alcohol and ether, and a small quantity of ammonia or trimethylamine (added to overcome the tendency of alcohol to cause corrosion). It is prepared by a fermentation process from sugar molasses in Natal.

Another account gives the composition of "Natalite" as 60 per cent. alcohol and 40 per cent. ether.

NATROLITE—A crystalline zeolite mineral, ordinarily described of the composition ($Na_2Al_2O_3,3SiO_2,2H_2O$); crystal system, No. 4, and sp. gr. 2·24. S. di Franco (*B.C.A.*, 1929, A, 905) gives the formula $Na_2Al_2Si_3O_{10},2H_2O$ to the natrolite of Viagrande (Etna). (See Zeolites.)

NATRON (Trona)—A crude native form of sodium sesqui-carbonate found in the soda-lakes of Egypt, Hungary, Magadi, Siberia, Thibet, and elsewhere; crystal system, No. 5. (See Sodium.)

NATURAL GAS—See Gas (Natural).

NAULI GUMS—See Gums and Resins.

NEAT'S-FOOT OIL—A pale yellow oil, of variable character and several grades, soluble in alcohol and ether, obtained in the process of boiling down ox, calves', and sheep's feet. Sp. gr., 0·914 to 0·918; sap. v., 194 to 199; i.v., 58 to 70; and ref. ind. at 20° C. of 1·469; used as a leather dressing, lubricant, and for oiling wool.

According to one published analysis, the sample examined contained 2 to 3 per cent. stearic acid, 17 to 18 per cent. palmitic acid, 74·5 to 76·5 per cent. oleic acid, and 5 to 10 per cent. glycerol.

"NECOL PLASTIC WOOD"—A material that can be moulded in the soft state and worked like ordinary wood in the dry form, capable of firm attachment to surfaces of wood, metal, or stone; useful for filling holes and making fillets on woodwork, etc. Half a pound of wet wood will cover about 1 square foot in a layer of $\frac{1}{16}$ inch thick; 8·2 ounces of the wet wood gives 3·8 ounces of dry material. (See Plastic Wood and Xylolith.)

NECTAR—A sugary juice which collects in the nectaries or discs of flowers, containing cane sugar together with uncrystallizable sugar. The total sugar in nectar from different Australian flowers has been determined as about 9 mg., or 6 per cent. of their weight. This nectar contains 70 to 90 per cent. water, and its concentration to a dry substance content of about 78 per cent. is effected in the sac of the bee. Other samples of nectar examined by O. W. Park contained from 40 to 55 per cent. sugar, the proportion varying considerably for any given source (*B.C.A.*, 1929, B, 612). (See Honey.)

NEEM OIL—Obtained from the seeds of the *Malia azadirachta* in the United Provinces and other parts of India. It contains sulphur, has an objectionable odour and bitter taste, and yields certain preparations by adequate treatment, said to be valuable remedies for syphilis and some skin diseases. With respect to its composition, see A. C. Roy and S. Dutt (*J.S.C.I.*, 1929, **48,** 333 T).

NEO—"New" or "recent."

"NEOCELLON"—A patented waterproofing solution made from cellulose acetate and nitro-cellulose, a suitable plasticizer (triphenyl phosphate, for example) being incorporated according to the nature of the application. A flame-proofing solution of aqueous character is also made and sold under this name, depending upon the employment of ammonium bromide and (or) ammonium phosphate, other components being incorporated to preserve the flexibility of the treated articles.

NEODYMIUM (Nd) **and its Compounds**—Atomic weight, 144·2; sp. gr., 6·9563; m.p. 840° C. An extremely rare element belonging to the cerium group, which has been isolated by the electrolysis of its anhydrous chloride, and stated to have three or four isotopic forms. It is silver-white in appearance, tarnishes in the air, and is attacked by hot water and dilute acids. It occurs in cerite, etc., and forms chloride ($NdCl_3$), nitrate, sulphate, bromide, and iodide, crystalline soluble salts of a rosy colour. An oxide (Nd_2O_3) of a pale blue colour is known, and the hydroxide ($Nd(OH)_3$) is obtained by adding alkali to a solution of its salts.

NEON (Ne)—Atomic weight, 20·18; sp. gr., 9·96; member of the argon group, more volatile than argon, supposed to be a mixture of atoms of masses 20 and 22, and exhibiting no decided chemical characteristics. It is present in the air to the estimated extent of only 1 part in about 66,000; is credited with several isotopic forms, exhibits a characteristic spectrum, and has been liquefied. Vacuum tubes charged with the gas and electricity produce a brilliant red light. The gas has a considerable penetrative power, and is used to some extent in landing lights, harbour lights for navigation purposes, and picturesque advertisements. The crystal structure of solidified neon has been described by J. de Smedt (with others) (*B.C.A.*, 1930, A, 671).

NEPETELLA OIL (*Calamintha nepeta* var. *canescens, Satureja nepeta*), sp. gr. 0·9227, contains 49 per cent. pulegone.

NEPHELINE (ELAETITE)—A mineral of the approximate composition ($3(Na_2K_2)O.4Al_2O_3,9SiO_2$), found in large deposits in the Murman Peninsula (Russia), which is likely to find useful application in glass-making, as a fertilizer, and in the ceramic industries.

NEPHELOMETRY—A kind of photometric chemical analysis dealing with the characters and size of particles in suspension and depending upon the comparison of scattered light from such precipitates. (See *Photometric Chemical Analysis*, vol. ii., "Nephelometry," by J. H. Yoe (Chapman and Hall, London); also Turbidimeters.)

NEPHRITE (Axestone or Beilstein)—See Jade.

NERNST'S HEAT THEOREM—A thermodynamic expression of the quantitative relation between the free and total energy changes of an interaction.

NERODOL—See Tannins.

NEROL ($C_{10}H_{18}O$)—An aromatic alcohol of rose odour, of sp. gr. 0·881 and b.p. 226° C., isomeric with geraniol, occurring in the finer extracts of rose and neroli.

NEROLI OIL—A reddish-yellow essential oil distilled from orange flowers, of which there are several varieties (*Citrus bigaradia* and *C. aurantium vulgaris*, etc.), soluble in alcohol, ether, etc.; used largely in perfumery and for flavouring. One ton of blossoms yields about 40 ounces of the oil, of sp. gr. about 0·87 to 0·88 at 15° C., opt. rot. 0° to +5°, and ref. ind. 1·468 to 1·4735. It contains terpenes, methyl anthranilate

NEROLI OIL *(Continued)*—

(C_6H_4,NH_2,CO_2,CH_3), linalyl acetate, linalool, and geraniol. Other varieties are obtained from the leaves and unripe fruit. Methyl anthranilate can be made from anthranilic acid and methyl alcohol by heating in presence of sulphuric acid, followed by distillation; its sp. gr. is 1·168, and it is soluble in alcohol and ether. (See Linalool and Orange Oil.)

NEROLINE (**Methyl-beta-naphtholate or β-Naphthyl-methyl-ether**) $(C_{10}H_7.OCH_3)$—A white crystalline body (m.p. 72° C.), soluble in alcohol and ether; prepared by heating a mixture of beta-naphthol, methyl alcohol, and zinc chloride; used in perfumery. Of the three ethers of β-naphthol, the methyl one is the body usually sold as "veroline"; m.p. 72° C. and b.p. 274° C.

NESSLER'S REAGENT—A solution of mercuric iodide in potassium iodide made alkaline by potassium hydroxide, which turns yellowish-brown even with traces of ammonia, for which it is a delicate test. (See H. Droop Richmond (*Analyst*, 1925, **50**, 67) and S. M. Naudé (*B.C.A.*, 1927, A, 311).)

NEURINE—See Choline.

NEUTRALIZATION—The removal of acidity or alkalinity from a solution to a neutral state by means of an alkaline or acid solution respectively, as tested by litmus-paper or other indicator. (See Chemical Compounds, p. 170; Litmus and Volumetric Analyses.)

NEUTRONS—Rays whose particles are indifferent to the strongest electrical and magnetic forces, for which a search is being made.

NICKEL (Ni) **and its Compounds**—Atomic weight, 58·69 with reputed isotopes 58 and 60; sp. gr., 8·9; m.p., 1,455° C. Nickel occurs in combination in a number of minerals (chiefly in combination with arsenic), including *kupfernickel* (Ni_2As_2), *white nickel* $(NiAs_2)$, *nickel glance* $(Ni_2(AsS)_2)$, *nickel blende* (NiS), and *melonite* (NiTe); also in association with cobalt in *speiss*. Kupfernickel deposits are found in North and South America, Norway, Germany, France, and Hungary, and other ore deposits occur in Ontario and New Caledonia, also at Blaaubank and in the Pelandsberg (Rustenberg) district of South Africa. (See also Pimelite, Millerite, Pentlandite, and Ullmanite.)

The metal can be obtained by heating the oxalate of nickel out of contact with air, or by reduction of the oxide with carbon at a high temperature. It is made commercially in large quantity both from the sulphide ores and the mineral *garnierite*, a hydrated silicate of nickel and magnesium $[(NiMg)O,SiO_2 + H_2O]$ found in New Caledonia and Oregon (the last named being first of all converted into sulphide) by roasting, in which the sulphur and arsenic constituents are for the most part burned off. The resulting mixed metallic oxides are subsequently heated to from 50° to 80° C. in a stream of "producer gas." (See Producer Gas.) By this (Mond's) process they are reduced to the metallic state, other than the nickel: this enters into combination with the carbon monoxide, forming nickel carbonyl $(Ni(CO)_4)$, which passes off in a vapourous state, and from it, the nickel is obtained by passage of the

NICKEL (*Continued*)—

gases through a pipe heated to about 180° C., whereby the mixture is resolved into gaseous carbon monoxide (which is used over again in fresh operations), the free metallic nickel being deposited in a lustrous mirror-like form. (See R. L. Mond (*J.S.C.I.*, 1930, **49,** 271 T and 283 T); and Grieb and Jones (*J. Inst. Chem.*, 1931, Part V., p. 291).) The Canadian manufacture by this process is described in *Chem. and Ind.*, 1927, **46,** 386, and the output in 1928 was estimated at 44,000 tons.

Nickel carbonyl in pure form (of b.p. 43° C. and sp. gr. 1·3185) can be obtained as a colourless volatile liquid, soluble in alcohol. The nickel used in making it is best prepared by reduction at 350° C. and cooled to 50° C. in a reducing atmosphere. Its vapour is poisonous and explodes at 60° C. The vapour pressure of nickel carbonyl has been measured by J. S. Anderson as between $-35°$ and $+43°$, and that of the liquid by the Rankine formula $\log p = 7{\cdot}690 - 1519/T$ (*J.C.S.*, 1930, p. 1656). (See F. W. Laird (*B.C.A.*, 1927, A, 533); C. F. van Duin (*Ibid.*, 1927, A, 743), and Metallic Carbonyls.)

There are also electrolytic processes for preparing nickel in the form of cathode plates from the roasted ore, after leaching with acid to remove most of the copper and otherwise. Certain defects in electrolytic nickel as ordinarily produced are overcome by the destruction of associated organic matter by means of chlorination or treatment with hydrogen peroxide. (See C. P. Madsen (*C.T.J.*, May 30, 1924); and, with respect to other factors, see article in the *Engineer,* by A. N. Campbell (*C.T.J.*, 1926, **78,** 42); *B.C.A.*, 1930, A, 1382; and C. Fink (*B.C.A.*, 1931, B, 930). The "Hybinette" nickel-refining process is described by F. E. Lathe (*J.S.C.I.*, 1925, **44,** 433 T and 443 T).)

Nickel is best known as a black powder, but can be obtained as a bright, lustrous, white, ductile, malleable, but tenacious metal of very hard character. It is used chiefly for toughening steel (a large consumption going into armaments); also in the manufacture of nickel-chromium-iron alloys of heat- and acid-resisting character and nickel-copper alloys; nickel-iron alloy for use in telegraphy; alloys for making coins used in Germany, Belgium, France, and the U.S.A.; for plating iron and steel articles (as it does not readily tarnish in the air); and as a substitute for tin in coating tin plates. While nickel is corroded to some extent in cooking operations—less than tin or aluminium—the preparation of food in nickel utensils is regarded as safe. It is said that nickel crucibles may be used for smelting minerals with potassium hydroxide but not with sodium hydroxide, and that small ones are suitable for determination of the gas content of coal (Pieters and Meylink, *B.C.A.*, 1929, B, 963). It exhibits resistance to many corroding agencies, being unaffected, or nearly so, by many acids and alkalies, and is employed to a considerable extent in the latter industry. It is one of the strongest non-ferrous metals, and is far superior to brass for many applications in the motor-car industry. It may possibly be used in the future for building the entire bodies of cars, while Edison has predicted its future use of one twenty-thousandth of an inch in thickness in place of paper, as it takes printers' ink to better effect.

NICKEL (*Continued*)—

The growing use of malleable nickel in chemical engineering is the subject of a special Bulletin issued by the Imperial Chemical House (see *C.T.J.*, 1931, **88**, 307; and **89**, 202).

For use as a catalyst the metal is prepared by heating the hydrated oxide, carbonate, formate, or oxalate at from 250° to 300° C. in the absence of air, although when obtained by reduction it is liable to contain some unstable hydrides. (See Waterman and Van Tussenbroek on the "Influence of Heat on the Preparation of Nickel Catalyst on Infusorial Earth" (*J.S.C.I.*, 1931, **50**, 227 T).) When used in connection with the hydrogenation of oils, it can be regenerated by removing the oil with a solvent, then treating the catalyst with some agent capable of dissolving the film of oxide on the metal, washing, and sealing it against access of air.

Nickel forms at least three oxides—NiO, Ni_2O_3, and Ni_3O_4—the monoxide being obtained by heating the nitrate, hydroxide, or carbonate, and there is some evidence of the existence of another oxide (NiO_2). The best method for preparing the pure monoxide is stated to consist in heating the nitrate to various temperatures. (See Prasad and Tendulkar (*J.C.S.*, 1931, p. 1404).) Nickel hydroxide ($Ni(HO)_2$) is obtained as a light green precipitate by adding an alkaline solution to a solution of a soluble nickel salt. The sesqui-oxide is obtained as a black powder by heating the nitrate to the point of decomposition, and the Ni_3O_4 as a grey residue of metallic appearance by heating the chloride to 400° C. in a current of oxygen.

The chloride ($NiCl_2$) (used in the preparation of sympathetic ink, etc.), nitrate ($Ni(NO_3)_2$), and sulphate ($NiSO_4,7H_2O$) which crystallizes in prisms, are all green in colour and soluble in water. The chloride, sulphate, and fluoride are used in nickel plating, the last-named salt giving a finer-grained deposit with high tensile strength and greater hardness. (See "Nickel Plating as a Corrosion Preventative," by S. Wernick (*Ind. Chem.*, 1929, v., 106).)

Several sulphides are known; of these, nickel monosulphide (N S) is black and insoluble in water and dilute acids.

The carbonate ($NiCO_3$) (a crystalline compound insoluble in water) occurs in nature as the mineral *zaratite*. The cyanide ($Ni(CN)_2.4H_2O$) (which is insoluble in water), the nitrate, the sulphate, the double nitrate of nickel and ammonium, and the double sulphate of nickel and ammonium ($NiSO_4.(NH_4)_2SO_4.6H_2O$) (which are soluble in water), are all used in nickel-plating; and the sulphate is used also as a mordant.

The compounds of nickel impart a reddish-yellow colour to a fused bead of borax, and some are used in the ceramic industries, the monoxide imparting a delicate brown colour to pottery. (See Alloys and Monel.)

NICOTINE ($C_{10}H_{14}N_2$)—An oily, colourless, alkaloidal liquid of sp. gr. 1·009 and b.p. 247° C., derived from pyridine, and constituting the acrid basic principle of the leaves of tobacco (*Nicotiana tabacum*), in which it is found present in amount varying from ½ to 9 per cent., together with a smaller quantity of another alkaloid named nicotianine.

NICOTINE (*Continued*)—

Nicotine is not present in the seed of the plants, but originates in the leaf and appears in the young plant immediately the chlorophyll begins to function. It is soluble in water, alcohol, and ether, and preparations of it are extensively used as insecticides for horticultural applications, also as dips for the destruction of ticks and other pests on the wool of sheep. It is used mainly against green fly (*Aphides*) and white fly (*Aleurodes*), but its application against caterpillars is limited. Being basic, it forms neutral salts and does not injure delicate plant tissues, so that in spray form nicotine washes can be used in respect of hops—the most delicate of crop plants. The sulphate of 40 per cent. strength and concentrated nicotine of 95 per cent. are two of the marketed forms. Professor Lefroy states that a common formula for a nicotine wash as used on hops is 6 to 10 lbs. of soft soap, with 6 to 10 ozs. nicotine per 100 gallons of liquid, and that no other substance compares with this in toxicity, making nicotine the most useful insecticide for horticultural purposes. (See "Nicotine Insecticides," by H. S. Carlos (*C.T.J.*, 1927, **80**, 579).)

The leaves of the plant also contain a large amount of extractives, albuminous bodies, some resin, and mineral salts which constitute the ash left upon burning amounting to from 18 to 23 per cent.

Havana and Manila tobaccos contain from 2 to 3 per cent. nicotine; Virginia and Kentucky from 4 to 5 per cent.; Rhodesian about 1·52 per cent.; and commoner varieties of French and German up to 9 per cent.; while it has been stated that thirty-six samples of South African tobacco showed a nicotine content ranging from 0·41 to 15·41 per cent.

Analyses of smoke have revealed the fact that about one-half of the nicotine in the tobacco smoked as cigars, cigarettes, and in pipes appears in the smoke.

Nicotine has been synthesized and forms a number of additive salts by combination with acids, such as the hydrochloride ($C_{10}H_{14}N_2.HCl$), all of which are soluble in water and poisonous.

See "The Determination of Nicotine in Tobacco," by R. Young (*Analyst*, 1927, **52**, 15); Couch (*B.C.A.*, 1927, B, 891); Vickery and Pucher (*J. Biol. Chem.*, 1929, **84**, 233); J. H. Reid (*Chem. and Ind.*, 1931, **50**, 954); Pyriki and Dittmar (*Analyst*, 1932, **56**, 407); Tobacco and Tobacco-seed Oil.

NIELLO-WORK—Ornamented silver and gold plates, the engravings on same being filled up with a black composition such as silver sulphide.

NIGROSINES—A class of black dyes prepared by heating aniline and its hydrochloride with nitro-benzene and a metal. They are of various solubilities—some in water, some in alcohol, and others in oil—and are used in making shoe polishes, varnishes, inks, and in the dyeing and leather trades.

NILE BLUE—An oxazine dyestuff.

NIOBE ESSENCE—See Methyl Benzoate and Perfumes.

NIOBITE—See Columbite.

NIOBIUM (Nb) **and its Compounds**—Atomic weight, 93·3; sp. gr., 7; m.p., about 1,700° C. A rare metal of grey colour and bright lustre, occurring in association with tantalum in a number of minerals found in Sweden and some parts of the U.S.A., including niobite (columbite, tantalite), which contains iron-manganese tantalate, with niobium in association [$(FeMn)(NbTa)_2O_6$].

The metal can be obtained from the tri-chloride by passage of its vapour together with hydrogen through a red-hot tube. It has not, so far, found any appreciable applications in industry; it fires when heated in air; is very inert; is not attacked by acids excepting a mixture of nitric and hydrofluoric acids; is hard as wrought-iron and combines with hydrogen and nitrogen.

Three oxides are known—viz., NbO, NbO_2, and Nb_2O_3; also two chlorides— viz., $NbCl_3$ and $NbCl_5$.

The recovery of niobium oxide from tungsten slags is referred to by C. Downie (*C.T.J.*, 1927, **80,** 338); see also *Ibid.*, 1931, **88,** 77.

NITON (Nt)—Atomic weight, 222. A rare inert substance described as a radium emanation element, soluble in water, and prepared by heating a radium compound or by dissolving it in water, pumping off the gases slowly generated from it, then removing any associated oxygen, hydrogen, carbon dioxide, and nitrogen, thus leaving the niton (which liquefies at from $-150°$ to $-170°$ C.), from which in turn the generated helium may be pumped off. It can be condensed to the solid state, and both it and the liquid forms are phosphorescent. It is stated to spontaneously decompose into helium and a solid radio-active substance.

N.B.—It must be left to physicists to explain the elemental character of radium, helium, and niton in view of these alleged chemical changes.

NITRAMINES (**Nitroamines**)—Amines containing a nitro group attached to the nitrogen atom, having the general character expressed by $R—NH—NO_2$, such as phenyl-nitramine ($C_6H_5.NH_2.NO_2$) and methyl-nitramine ($H_3.NH.NO_2$).

NITRANILINES ($C_6H_4NH_2.NO_2$)—There are three of these compounds (ortho, meta, and para) produced by nitration of aniline following upon acetylation. All are yellow, crystalline, and readily soluble in alcohol, melting respectively at 71·5°, 114°, and 148·3° C.; the para compound is used in making para-nitraniline red.

The *o* nitraniline exists in two polymorphous crystalline forms. (See Dippy and Hartshorne, *J.C.S.*, 1930, p. 725.)

There are also di- and tri-nitranilines, the tri- compound being the yellow crystalline body known as picramide, m.p. 188° C.

"NITRAPO"—See Potassium Nitrate.

NITRATES—See Chemical Compounds (p. 170) and Nitrogen Compounds (pp. 615 and 619).

NITRATION—A term given to the process by which, using generally strong nitric acid (or a mixture of that acid with concentrated sulphuric acid), the nitro group ($—NO_2$) is introduced into organic compounds, as illustrated by the production of nitro-benzene ($C_6H_5NO_2$) and di-

NITRATION (*Continued*)—
nitro-benzene ($C_6H_4(NO_2)_2$) from benzene (C_6H_6). Again, toluene (C_7H_8) can, by the action of strong nitric acid, be converted successively into mononitro-toluene ($C_7H_7NO_2$), dinitro-toluene ($C_7H_6(NO_2)_2$), and trinitro-toluene ($C_7H_5(NO_2)_3$). (See Explosives.)

NITRE—See Potassium Compounds.

NITRE CAKE—See Sodium Compounds, p. 830.

NITRIC ACID—See Nitrogen Compounds and Nitrogen Fixation.

NITRIC ESTERS—See R. C. Farmer, *J.S.C.I.*, 1931, **50**, 76 T.

NITRIC ETHER—See Esters (Ethyl Nitrate).

NITRIDES—Boron, magnesium, lithium, silicon, titanium, and some other elements combine with nitrogen at a red heat to form nitrides, and these are decomposed by the agency of steam, thus yielding ammonia. Some can be obtained by passing ammonia gas over the metals heated in porcelain tubes to from 400° to 800° C., which effects the decomposition of the ammonia.

The nitrides TiN, VN, Si_3N_4, BN, LaN, ZrN, ScN, NbN, and ErN have all been obtained by heating the corresponding oxides with the calculated weight of carbon to 1,250° C. in an atmosphere of nitrogen. Aluminium nitride is now an article of some commercial importance. An iron nitride (Fe_4N_2) is formed when an arc, using a current of 3 to 10 amp. at 35 volt, is struck between iron electrodes in a quartz bulb in an atmosphere of nitrogen (E. Willey, *J.C.S.*, 1928, pp. 2840-2844; cf. A, 1928, 3). (See also S. A. Vosnessenski (*B.C.A.*, 1930, A, 178) and Aluminium, p. 37.)

NITRIFICATION—A process by which ammonia and other nitrogenous organic substances present in soil are converted into nitrates by the action of micro-organisms. Ammonium carbonate, for example, is first of all oxidized and converted into a nitrite by the agency of micro-organisms of one kind, and this is changed by another class of micro-organisms into the state of nitrate, the process requiring the presence of a base. It is known that the presence of calcium sulphate (gypsum) greatly facilitates the nitrification of urine.

Nitrifying micro-organisms exist to a depth of about 6 feet in soil and are most active between 12° and 37° C., but nitrification is practically confined to the surface, air being essential. The purification of sewage by filtration through soil is largely due to this process.

It has been demonstrated that one part of boric acid in two and a half million parts of nutrient solution greatly increases the activity of the bacteria which fix atmospheric nitrogen. (See P. Tuorila (*B.C.A.*, 1929, A, 473), and O. Meyerhof and D. Burk (*Ibid.*).)

Bacterial denitrification is said to be a process of the reduction of nitrates in anaerobic conditions, the necessary energy being supplied by the oxidation of organic matter (M. P. Korsakova, *B.C.A.*, 1928, A, 1056). (See Bacteria, Sewage, and Soil.)

NITRILES (Alkyl Cyanides)—Compounds containing the group—CN; they may be viewed as derivatives of hydrocyanic acid, the hydrogen in the HCN being replaced by radicals—for example, aceto-nitrile or methyl cyanide ($CH_3.CN$) and ethyl cyanide (C_2H_5CN).

NITRITES—See p. 171 and Nitrogen Compounds (p. 619).

NITRO—The univalent group —NO_2.

NITRO-BENZENE (Oil of Mirbane, Artificial Oil of Bitter Almonds) [$C_6H_5(NO_2)$] is a yellowish liquid of sp. gr. 1·204 and b.p. about 211° C., which solidifies when cooled, and is prepared from benzene by the action of a mixture of sulphuric and nitric acids, or by the action of strong nitric acid on turpentine. It may be distilled without decomposition, has an intense odour of oil of bitter almonds, is soluble in alcohol and ether, and much used in perfumery and flavouring, also in the preparation of aniline and otherwise in the dye industry.

There are several dinitro-benzenes ($C_6H_4(NO_2)_2$) and trinitro-benzenes ($C_6H_3(NO_2)_3$) respectively.

NITRO-CALCITE—Native calcium nitrate.

NITRO-CELLULOSE (Nitro-Cotton)—Its preparation, as used in film-making, starts with cotton, which, when washed and dried, is subjected to the action of a mixture of sulphuric and nitric acids until it has taken up the desired amount of nitric acid, when it becomes soluble. After washing and mixture with appropriate solvents, it is coated over a wheel of large diameter, on which the film is formed by evaporation of the solvents.

It can also be made from wood-pulp and straw-pulp, but these products differ in viscosity, stability, and other respects from each other and from that made from cotton. Industrial nitro-cellulose products, as used in making various lacquers, varnishes, enamels, "finishes," artificial silk, leather, linoleum, etc., are described by H. Hepworth (*Ind. Chem.*, 1925, i., 290 and 323). The viscosity of nitro-cotton solutions depends upon their momentary physical states, which are necessarily variant in character.

Nitro-cellulose is stated to decompose exothermally under all circumstances, the decomposition being mainly dependent on the content of certain impurities. (See O. C. Ellington (*J.S.C.I.*, 1929, **48**, 267 T); A. H. Bresser on "The Manufacture and Stabilization of Nitro-Cellulose" (*Ind. Chem.*, 1930, vi., 249); M. G. Millikin on "Nitro-cellulose of Low Viscosity" (*Ind. Eng. Chem.*, April, 1930); and J. Goujon on "Improved Taliani Stability Test for Nitro-cellulose" (*B.C.A.*, 1932, B, 208); Celluloid, Collodion Cotton, Explosives, Lacquers, and Pyroxylin.)

"NITRO-CHALK"—A fertilizer consisting of ammonium nitrate and dried Billingham calcium carbonate, containing 15½ per cent. of nitrogen, of which it has been alleged that one half is in the nitrate form and the other half in ammoniacal form. (See Nitrogen Fixation, p. 620.)

NITRO-CHLOROBENZENE (ortho and para) (C_6H_4Cl,NO_2)—Crystalline intermediates soluble in alcohol and ether, m.p. 15° and 83° C.

NITROGEN and its Compounds—Nitrogen (N)—atomic weight 14·008, and m.p. −210·5° C.—is contained in the air, of which it constitutes

NITROGEN (*Continued*)—

about four-fifths, the amount being estimated at approximately 30,000 tons over every acre of land and sea. In combination, it occurs as crude sodium nitrate ($NaNO_3$) in Chile nitre (Chile saltpetre) found in Chile, Peru, and elsewhere, and is largely employed as a nitrogenous fertilizer. It is also found in combination as potassium nitrate in the form of *nitre* or saltpetre (KNO_3) in certain soils in India and Ceylon, and is a constituent of many animal and vegetable substances.

It is produced commercially by the liquefaction of air and boiling off the nitrogen at $-195{\cdot}7°$ C.; while by the "Borsig" process methane is burned in air, thus producing carbon dioxide (which is absorbed under pressure in water) and dry nitrogen of 99 per cent. purity. As thus made it is used in the manufacture of calcium cyanamide and synthetic ammonia. (See Coke Ovens (Gas), Oxygen, p. 655, and Nitrogen (Fixation), p. 620.)

It is obtainable in a pure state by passing ammonia gas over nickel powder in a quartz tube at 1,000° C., any residual ammonia being frozen out by liquid air (P. Harteck, *B.C.A.*, 1930, A, 438). It is said to have several isotopes, one of 15 according to Naudé, and this G. Herzberg claims to have confirmed (*B.C.A.*, 1930, A, 1084).

Nitrogen can be readily made in the laboratory from the air by abstraction of the oxygen—for example, by the use of alkaline potassium pyrogallate solution, which having a great affinity for oxygen, speedily absorbs it from air confined in a closed vessel, and leaving the nitrogen unabsorbed. (See Eudiometer.) Similarly, when phosphorus is burned in air it combines with the oxygen to form phosphorus pentoxide, leaving nearly pure nitrogen.

It can also be made by passing a stream of air over metallic copper heated to redness, when the oxygen of the air combines with and is fixed by the copper, forming cupric oxide, nitrogen gas passing over.

When maintained under great pressure (from 300 to 1,800 lbs. per square inch) in contact with water, under certain conditions, ammonium nitrite is formed.

Every living thing contains nitrogen, which when pure is a colourless gas without taste or smell, nearly insoluble in water (1 volume of which at 0° C. dissolves only 0·0235 volume of the gas), and is in its free state a very inert chemical substance exhibiting but little tendency to enter into chemical combination with other substances. It can, however, be prepared in a much more chemically active—and therefore probably allotropic (possibly atomic)—form by an electrical process.

A corona discharge at 20,000 volts from a fine wire is stated to be capable of transforming 4 per cent. pure nitrogen into an activated form, in which state it readily effects the decomposition of hydrocarbons, combines with hydrogen to form ammonia, combines with oxygen to form oxides, and with various metals to form nitrides. It is more stable than activated hydrogen, and persists for some hours, exhibits a glow, and attacks acetylene and other gases containing carbon, thus producing cyanogen compounds. Evidence has also been obtained that nitrogen may be chemically active and yet show no

NITROGEN (*Continued*)—

luminosity. (See E. J. B. Willey (*J.C.S.*, 1927, pp. 2189 and 2831; *Ibid.*, 1928, p. 2840; 1930, pp. 336 and 1146; and 1932, pp. 142 and 153); C. N. Hinshelwood (*Nature*, 1928, **122,** 404); Rayleigh (*Nature*, 1929, **123,** 716); Jackson and Broadway (*Proc. Roy. Soc.*, 1930, **A 127,** 678); Tiede and Chomse (*B.C.A.*, 1930, A, 1139); S. H. Bastow (*J.C.S.*, 1931, p. 1950); and Metastability.)

The consumption of nitrogen in its various forms for fertilizing purposes in the United Kingdom and Ireland is estimated at about 6½ lbs. per acre of arable land.

Ammonia (NH_3)—One of the most important combinations of nitrogen is ammonia, the salts of which are largely obtained from the *ammoniacal liquor* of gasworks, for which purpose the gas liquor is treated with lime and distilled, the ammonia being thus driven over and condensed in water, or passed into sulphuric or hydrochloric acid, forming respectively ammonium sulphate [$(NH_4)_2SO_4$], or chloride (NH_4Cl). The economic recovery of ammonia in the gas industry is the subject of a paper by P. Parrish (*C.T.J.*, 1928, **83,** 339); an improved apparatus for effecting the recovery (*C.T.J.*, 1931, **88,** 149); and the dephenolizing of ammonia liquors by the use of activated carbon (*Ind. Chem.*, 1930, vi., 327).

Cobb's process for recovering ammonia from coal consists in washing the gas in a solution of zinc sulphate, thus causing the precipitation of zinc sulphide, accompanied with the production of ammonium sulphate in solution. The zinc sulphide is filtered off and roasted, thus producing the oxide and sulphur dioxide gas, and by suspending the oxide in water and exposing it to the roaster gas, zinc sulphate is regenerated for use over again. The ammonium sulphate is recovered from its solution by evaporation.

Pure (liquefied) ammonia boils at $-33{\cdot}5°$ C., can be thermally decomposed by exposure to various surfaces at temperatures ranging from 631° to 1,215° C., and is very soluble in water, which, at the ordinary temperature of the air, absorbs 727 times its own volume of the gas, and at 0° C. 1,148 volumes. The solution is colourless, strongly alkaline, and of characteristic pungent odour. A solution containing 35 per cent. of ammonia gas dissolved in water, having a sp. gr. of 0·882 at 15° C., is known as *liquor ammoniæ*, and it is also marketed of sp. gr. 0·920.

Two types of ammonia may be prepared—an active one by slow withdrawal from a cylinder of the compressed gas (and otherwise), and the inactive one by rapid evaporation of the liquefied gas, and they are decomposed by means of a strong electrically heated platinum wire to different extents by the same quantity of energy.

Ammonia has been produced on a commercial scale from a mixture of nitrogen and hydrogen gases contained under pressure and exposed to a high temperature, using a catalytic agent to effect the combination. This and some other processes of production are described under the heading of Nitrogen Fixation (pp. 620-623.) The "Bucher" process of manufacture is conducted by passing nitrogen through a heated mixture of coke, soda-ash, and iron compounded in the form of

NITROGEN (*Continued*)—

briquettes; sodium cyanide is thus produced, and this, when hydrolysed by steaming, yields ammonia.

The cyanamide process for the production of ammonia is referred to elsewhere. (See Cyanamide.) As produced by this process, it can be oxidized to make nitric acid, or converted into sulphate or phosphate (by a process which is planned also to obtain phosphoric acid from phosphate rock).

Ammonia is the simplest form of the class of bodies described as amines, and is in fact the prototype of organic bases.

The hypothetical ammonium radical (NH_4) capable of replacing an atom of hydrogen in acids has not been isolated.

Ammonia is extensively and variously used as a detergent, saponifying agent, in electro-deposition and in connection with refrigerating appliances, while some of its salts are employed for rendering wood and other materials non-inflammable. In 1913 the world's ammonia production in terms of sulphate amounted to 1,389,790 tons, the essential sources being gasworks, coke-ovens, gas producers, shaleworks, ironworks, and bone and other carbonizing works. At this time of writing there is stated to be a world overproduction of ammonia, and in the U.S.A. ammonia is being cracked to some extent as a source of hydrogen and nitrogen by passage over an electrically heated catalyst. Its use has also been advocated for treating water in association with chlorine, chloramine being thus formed and neutralizing any excess of chlorine used for its purification. Cracked ammonia is also stated to be of use in all the standard kinds of welding, and ammonia itself can be employed for nitriding steel and thus hardening it. (See H. W. Strong (*Ind. Chem.*, 1927, iii., 403); An Ammonia Cracker (*Ibid.*, 1932, viii., 117); *The Design and Working of Ammonia Stills*, by C. C. Carpenter (E. Benn, Ltd.); Ammonia-Still Effluent, Coal, Nitrogen Fixation (p. 620), and Tar.)

Ammonium Sulphate [$(NH_4)_2SO_4$] is a white soluble salt of m.p. 140° C., and constitutes an efficient weed-killer, while it is also largely used as a nitrogenous fertilizer and for the manufacture of ammonia-alum (see Alums) and other compounds. The commercial qualities of sulphate usually contain 0·4 per cent. acid and about 3 per cent. moisture, but is marketed also as containing 21·1 per cent. N. Large quantities are now produced by the various processes described under Nitrogen (Fixation). There is also a process for obtaining this salt by treating very finely divided gypsum with ammonium carbonate, when, owing to the smaller solubility of calcium carbonate than that of calcium sulphate, reaction occurs, producing ammonium sulphate and calcium carbonate. The reaction is a so-termed reversible one—

$$CaSO_4 + (NH_4)_2CO_3 \Longleftrightarrow CaCO_3 + (NH_4)_2SO_4$$

(See B. Waeser, *B.C.A.*, 1931, B, 18.)

In one method of procedure calcium sulphate suspended in a solution of ammonia is passed down a series of pipes carrying a current of carbon dioxide and steam in the opposite direction, resulting in the

NITROGEN (*Continued*)—

production of a mixture of calcium carbonate in 30 per cent. ammonium sulphate, 90 per cent. of the sulphuric acid being recovered from the gypsum. The calcium carbonate retains, after filtering, about 0·5 per cent. nitrogen and is useful as a low-grade fertilizer.

Another process consists in producing ammonium sulphite in such form that it is readily converted into sulphate by air. Ammonia vapour and water in vapour or fine spray form are caused to react with a mixture of sulphur dioxide gas and air in a chamber at just below 100° C., by which means the sulphite is produced and precipitated, after which it is exposed in heaps or shallow deposits and raked from time to time, thus changing it in the sulphate. (See T. Parrish, *C.T.J.*, 1926, **79,** 98 and 471.) What would appear to be a modified form of this process consists of the use of a catalyst-sulphito-cobalt-ammonia complex —which effects the atmospheric oxidation without any external heating. (See *C.T.J.*, 1930, **87,** 504.)

The "Electro-Nitrogen" process, as developed by M. R. Tern, depends upon the interaction of ammonia vapour and sulphur trioxide (as made from sulphur dioxide gas in an electric arc) in an electrostatic precipitation plant in which the ammonium sulphate is separated. It is particularly directed to the recovery of sulphur from spent gas purifier material.

The "C.A.S." process, of the Koppers Co. of Esson, for recovery of ammonium sulphate from raw coke-oven gas consists first of all in freeing it from tar and other associated impurities, and then concentrating the ammonia water to from 8 to 12 per cent. strength. The ammonia is subsequently converted into polythionate, which is afterwards, by autoclaving, resolved into ammonium sulphate and sulphur. Incidentally, the cyanogen and hydrogen sulphide contained in the coke-oven gas are also recovered. (See *Ind. Chem.*, 1930, vi., 10, and 1931, vii., 517.)

A description of the "Wilton" plant at the Granton Gasworks of the Edinburgh Corporation is given in the *Ind. Chem.*, 1930, vi., 189.

The production of ammonium sulphate in 1914 in the United Kingdom was as follows:

Gasworks	176,000 tons.
Ironworks	16,000 ,,
Shaleworks	63,000 ,,
Coke and carbonizing and producer gasworks	171,000 ,,
Total	426,000 ,,

The amount of ammonia products produced in gasworks and other works in England and Scotland only in 1924, expressed in terms of sulphate (25¾ per cent. NH_3), was, according to the Alkali Inspector's Reports for that year, 362,180 tons, and the total world production 2,500,000 tons.

The production of ammonium sulphate in Great Britain and Ireland amounted to 865,878 tons in the fertilizer year 1929-30.

NITROGEN (*Continued*)—

Ammonium Persulphate [$(NH_4)_2S_2O_8$] is made by electrolyzing a solution of ammonium sulphate dissolved in dilute sulphuric acid (1 part to 7 parts water) in a divided cell. It is soluble in water and used in electro-plating, photography, etc. It has been reported as explosive under conditions causing oxidation of the ammonium radical, and particularly so if the salt comes into contact with organic matter.

Ammonium Nitrate (NH_4NO_3) is a colourless salt of m.p. about 154° to 160° C., and as prepared from ammonia and nitric acid is used in the making of the explosive named "Roburite" and as a fertilizer.

During the Great War ammonium nitrate was produced by a process which consisted of the double decomposition of Chile saltpetre and ammonium sulphate as expressed in the equation:

$$2NaNO_3 + 2(NH_4)_2SO_4 = 2NaSO_4 + 2NH_4NO_3.$$

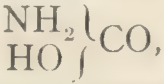
Another process used during the Great War consisted of passing carbon dioxide into strong ammonia liquor in a tower and introducing the carbonate thus formed into a solution of calcium nitrate, the precipitated calcium carbonate being removed by filtration, and the ammonium nitrate being subsequently crystallized from the resulting evaporated liquor. Partial decomposition occurs during concentration of the solution, and it has recently been ascertained that this is largely obviated by addition of a small amount of phosphoric acid or aqueous solution of superphosphate. (See *C.T.J.*, 1931, **88**, 453.)

Ammonium Chloride (NH_4Cl)—There are several processes of manufacture; in one, ammonia gas is passed into hydrochloric acid (see *C.T.J.*, 1927, **81**, 77). The difficulties experienced in its preparation by the direct combination of hydrochloric acid and ammonia in the gaseous phase are dealt with by F. Frietag. (See *C.T.J.*, 1930, **87**, 477.) By another, it is made by action, under pressure, of ammonia and carbon dioxide upon brine as realized in a modified form of the ammonia-soda process. (See *C.T.J.*, 1927, **80**, 77, and K. Kieper (*Chemiker Zeitung*, No. 6, 1930).) As manufactured by the reaction between ammonium sulphate and alkali chlorides, and as prepared from gas and other ammoniacal liquors by treatment with hydrochloric acid, it is subsequently purified by sublimation, and is a colourless, crystalline substance, soluble in cold water to the extent of about 33 per cent., and is known commercially by the name of "sal-ammoniac." Its vapour appears to be completely dissociated at between 200° and 400° C. (Braune and Knoke, *B.C.A.*, 1928, A, 829.) It is used in medicine, in dyeing operations, in electric batteries, as a fertilizer, in the tinning and soldering trades, in galvanizing, and in the preparation of a cement (made of iron filings mixed with 1 or 2 per cent. sulphur and moistened with a solution of the sal-ammoniac) for fixing iron in stonework.

Ammonium Carbonates—There are several carbonates, the commercial article being made by heating a mixture of ammonium sulphate and ground chalk to redness and condensing the generated vapours, the

NITROGEN (*Continued*)—

product being a mixture of ammonium—hydrogen carbonate (or so-called bicarbonate) [$(NH_4)HCO_3$] and ammonium carbamate—from which the carbamate can be washed out with alcohol, and has a strong ammoniacal odour. For the conditions under which the bicarbonate can be produced by the equation $NH_3 + CO_2 + H_2O \Longleftrightarrow (NH_4)HCO_3$, see W. H. Hutchison (*J.C.S.*, 1931, p. 410).

Ammonium Carbamate [$(NH_3)_2CO_2$ or $(NH_4)CO_2(NH_2)$] is a white, crystalline, volatile, and soluble powder described as the "anhydride" of ammonium carbonate, formed by the interaction of dry ammonia gas and carbon dioxide. It is otherwise described as the ammonium salt of the unknown carbamic acid  $\left.\begin{matrix}NH_2\\HO\end{matrix}\right\}CO$, and it can also be made by the action of carbonyl chloride upon ammonia:

$$COCl_2 + 4NH_3 = CO(NH_2)_2 + 2NH_4Cl.$$ (See Urea.)

Ammonium Carbonate [$(NH_4)_2CO_3$] (the normal carbonate) can be obtained by passing ammonia gas into a strong solution of the commercial compound, when the carbamate becomes converted into the normal carbonate by the action of water, and the bicarbonate content is also changed into the same product by the action of ammonia. Upon exposure to air it gives off ammonia and is changed back to the compound NH_4HCO_3, a body which, when crystallized in a pure, dry state, does not smell of ammonia. It is used as a fertilizer, in making smelling salts, and in a number of industries. (See Nitrogen (Fixation).)

Sal-volatile is a dilute solution of ammonium carbonate.

Ammonium Chlorate (NH_4ClO_3), obtained by the addition of ammonium chloride to a solution of sodium perchlorate, is a colourless soluble salt used in the manufacture of explosives.

Ammonium Phosphate [$(NH_4)_2HPO_4$]—A white, crystalline salt, soluble in water, made by the interaction of ammonium hydroxide and phosphoric acid; used in medicine, fireproofing, etc. An electrical process for the production of ammonium phosphate from calcium phosphate is in course of development in France. (See *Chem. and Ind.*, 1928, **47**, 1021.)

Ammonium Formate—See Hydrocyanic Acid.

Ammonium Sulphide [$(NH_4)_2S$]—A yellow, crystalline substance, soluble in water and alcohol, used in the textile industry.

The solutions obtained in water by the interaction of ammonium hydroxide and hydrogen sulphide are of indefinite constitution, and contain a number of sulphides.

Ammonium sulphide vapour can be quantitatively transformed into ammonium sulphite and sulphate by atmospheric oxidation at 450° to 650° in presence of a suitable catalyst (Appleby and Lanyon (*J.C.S.*, 1926, p. 2983).)

So-called ammonium polysulphide has been found useful as a fungicide for the control of apple, rose, and gooseberry mildews, its value

NITROGEN (*Continued*)—

being in relation to its polysulphide sulphur content, and its efficiency on its wetting and spreading properties, so that it is best used as a spray.

Ammonium Disulphide [$(NH_4)_2S_2$] is generally obtained as a yellow oil by heating the pentasulphide; it sets on standing to a mass of lemon-yellow, needle-shaped crystals.

Ammonium Sulphocyanide (**Sulphocyanate**) (NH_4SCN)—A colourless deliquescent, crystalline body, soluble in water and alcohol; marketed of 95 per cent. strength.

Ammonium Pentasulphide [$(NH_4)_2S_5$] has been prepared by the action of sulphur on solutions of ammonium hydrosulphide in dry alcohol, and can be obtained in orange-yellow crystals.

Ammonium Chromate [$(NH_4)_2CrO_4$] and the **Ammonium Dichromate** [$(NH_4)_2Cr_2O_7$] are yellow, crystalline, soluble salts used as mordants.

Ammonium Difluoride [$(NH_4)HF_2$] is a white, crystalline, soluble salt used in the ceramic industry and as a sterilizing agent in brewery work.

Ammonium Tartrate [$(NH_4)_2C_4H_4O_6$] is a white, crystalline, soluble salt used in the textile industry.

Ammonium Ditartrate [$(NH_4)H.C_4H_4O_6$] is a white, crystalline, soluble salt used in making baking-powders.

Ammonium Bromide (NH_4Br) is a colourless, crystalline, soluble salt used in photography and medicine.

Ammonium Oxalate [$(NH_4)_2C_2O_4.H_2O$] is a colourless, crystalline, soluble salt frequently used as an analytical reagent.

Ammonium Perchlorate [$(NH_4)ClO_4$] is a white, crystalline, soluble salt used in pyrotechnics and making explosives.

Ammonium Phospho-molybdate ($2(NH_4)_3PO_4,22MoO_3,12H_2O$) is a yellow, crystalline, soluble salt used as an analytical reagent.

Ammonium Vanadate (NH_4VO_3) is a white, crystalline salt soluble in warm water, used as a mordant and in preparation of vanadium salts, etc.

Ammonium acetate [$(NH_4)C_2H_3O_2$], benzoate [$(NH_4)C_7H_5O_2$], borate [$(NH_4)_3BO_3$], salicylate [$(NH_4)C_7H_5O_3$], valeriate [$(NH_4)C_5H_9O_4$], are all used medicinally. (See also Hydroxylamine and Molybdenum (Ammonium Molybdate).)

Nitrogen Oxides—There are six of these, having the formulæ N_2O, NO, N_2O_3, NO_2, N_2O_4, and N_2O_5; and there are three acids corresponding respectively to the oxides: N_2O, N_2O_3, and N_2O_5.

Nitrous Oxide (**Nitrogen Monoxide**) (N_2O), known also as laughing gas, can be obtained by heating ammonium nitrate to 205° C., when it splits up into N_2O and water:

$$NH_4NO_3 = N_2O + 2H_2O,$$

or by heating a mixture of sodium nitrate and ammonium sulphate to

NITROGEN (*Continued*)—

230° C. and collecting the gas over mercury. Its direct synthesis by the action of an electric discharge through nitrogen at low pressure in presence of oxygen under certain conditions has been effected. (See Chapman, Goodman, and Shepherd, *J.C.S.*, 1926, p. 1404.)

It is a colourless gas, soluble in water to the extent of 1·305 volumes in 1 volume of water at 0° C.; of a faint not unpleasant odour, and when breathed for a short time induces excitement and in some cases laughter. It is used to some extent as an anæsthetic in dentistry, and is easily liquefied to a colourless, mobile fluid which can be frozen solid. Liquid nitrous oxide boils at $-88 \cdot 7°$ C. and solidifies at $-102°$ C. (See Hydrazoic Acids.)

Nitric Oxide (NO) gas is generated by the action of nitric acid of sp. gr. 1·2 upon copper or mercury, when the nitrate of the metal passes into solution. It is colourless, and enters into combination with atmospheric oxygen to form red-brown, irritating vapours of nitrogen peroxide. On the surface of heated platinum at 1,000° to 1,500° it is dissociated as follows: $2NO = N_2 + O_2$.

Nitrogen Trioxide (N_2O_3) is made by exposing a mixture of nitric oxide and nitric peroxide to a temperature of $-20°$ C., when it is produced as a bluish-green fluid.

Nitrogen Peroxide (NO_2) can be prepared by passing a mixture of 2 volumes of nitric oxide with 1 volume of oxygen through a tube surrounded by a freezing mixture. At low temperatures it forms a colourless, crystalline compound which melts at $-9°$ C., and at higher temperatures it takes on a yellow and then an orange colour. It boils at 22° C., and gives off reddish-brown vapours; in fact, it is dissociated as the temperature rises, and at 140° C. it is entirely resolved into NO_2, so that the crystalline substance from which it is produced is, for various reasons, regarded as having the constitution represented by N_2O_4.

An investigation made on behalf of the Medical Research Committee provided evidence that the so-called "active oxygen" of fresh country air is not ozone, but nitrogen peroxide. This, however, cannot be regarded as altogether correct, for although it may at times be present as a result of electrical action (lightning), hydrogen dioxide is more often present as an atmospheric constituent, particularly in the neighbourhood of pine woods, and gives the same reactions. (See Hydrogen dioxide.)

Nitrogen Pentoxide (N_2O_5) is a white, solid, crystalline substance which melts at 30° C. with partial decomposition, and when suddenly heated, is apt to explode with violence, while in contact with water it produces nitric acid:

$$N_2O_5 + H_2O = 2HNO_3.$$

It can be prepared by withdrawing the elements of water from nitric acid by means of phosphorus pentoxide:

$$2HNO_3 + P_2O_5 = 2HPO_3 + N_2O_5,$$

NITROGEN (*Continued*)—

the mixture being cautiously made and kept cool at first, and then gently heated, when the N_2O_5 distils over and can be condensed in a refrigerated receptacle.

Hyponitrous Acid ($H_2N_2O_2$) is an unstable substance, and has no present commercial importance.

Nitrous Acid (HNO_2) is not known in the pure state, but its salts (the nitrites) are stable compounds, and can be prepared by heating the nitrates above their fusion-point, when oxygen is given off and the nitrites are obtained by this reduction; for example:

$$KNO_3 = KNO_2 + O.$$

Most of the metallic nitrites are soluble in water, and when they are subjected to the action of dilute acids they are decomposed, brown vapours being given off, whereas the nitrates are stable under this treatment.

Nitric Acid (HNO_3) is a very important compound, and is formed in a variety of ways, but the method by which it has in the past been mainly produced is by the action of sulphuric acid (H_2SO_4) upon sodium nitrate ($NaNO_3$). The first stage of the process is represented by the equation:

$$NaNO_3 + H_2SO_4 = NaHSO_4 + HNO_3,$$

and by pushing the heating further there is a secondary change, as follows:

$$NaNO_3 + NaHSO_4 = Na_2SO_4 + HNO_3.$$

This operation is generally carried out in cast-iron eggs or cylinders lined with fire-clay, the nitric acid passing over in the form of vapour which is condensed.

In practice, nearly equal parts of purified Chile nitrate and sulphuric acid are subjected to distillation, the strength of the acid which is employed depending upon the kind of nitric acid that is required, concentrated sulphuric acid of about 160° Twaddell being used for making strong nitric acid, and that of about 140° Tw. (ordinary Glover tower acid) being used for production of weak nitric acid. Commercial grades of various strengths are made from 36° to 44° Baumé and 80° Tw., while so-called "aqua fortis" acid of 41½° B. contains 65·67 per cent. real HNO_3. An account of the process, as carried out at one of Nobel's explosive factories, is given in the *Ind. Chem.*, 1926, ii., 531. (See Sodium (Hydrogen Sulphate), p. 830.)

The so-called "fuming" nitric acid contains upwards of 86 per cent. HNO_3, and has a specific gravity of about 1·48. It is very corrosive, and in contact with many organic substances causes their combustion.

In the "Valentiner process" the decomposition of the sodium nitrate is effected in glass retorts *in vacuo*—that is, under reduced pressure—by which means the production of nitrous acid as an impurity is avoided, and there is no escape of acid fumes into the atmosphere.

NITROGEN (*Continued*)—

Nitric acid can now, however, be made more cheaply by oxidation of ammonia.

Nitric acid is colourless when pure, and is a strongly fuming hygroscopic corrosive liquid with a sp. gr. of 1·53, which attacks many metals with avidity and forms by combination therewith, or by reactions with their oxides or carbonates, a large number of corresponding nitrates. The action of the acid on some metals is the subject of a paper by E. S. Hedges (*J.C.S.*, 1930, p. 561).

It is a powerful oxidizing agent, and its uses in industrial chemistry are many and of great importance, including its employment in the manufacture of the explosives nitro-glycerine, gun-cotton, etc. (See Explosives.)

Nitrates in the soil are produced by the slow oxidation of ammonia (derived from nitrogenous organic matter) in the presence of air and an alkali, and it has been conjectured that this process possibly accounts for the natural deposits found in Chile and elsewhere. (See *The Manufacture of Nitric Acid and Nitrates*, by A. Cottrell (Gurney and Jackson, London); Nitrification and Nitrogen Fixation.)

Nitrogen Trichloride—Obtained from ammonium chloride by the action of chlorine ($NH_4Cl + 3Cl_2 = NCl_3 + 4HCl$)—is a thin, oily, very volatile liquid of pale yellow colour and sp. gr. 1·65, having an irritating pungent odour. It is one of the most dangerous explosives, decomposing with great violence when exposed to sunlight or brought into contact with grease, turpentine, and many other substances.

There is a corresponding bromide (NBr_3) obtained, as is thought, by addition of potassium bromide to nitrogen trichloride beneath water.

Nitrogen Tri-iodide is a crystalline body represented by the formula $N_2H_3I_3$. It is produced by addition of strong ammonia solution to powdered iodine and is also formed when dry ammonia acts on the less stable dibromoiodides (Cremer and Duncan, *J.C.S.*, 1930, p. 2750).

Nitrogen Trifluoride has been obtained as a liquefiable colourless gas. (See Ruff (with others), *B.C.A.*, 1928, A, 854.)

NITROGEN FIXATION—The nitrogen fixation processes now operating are primarily used for the production of fertilizers, the surplus ammonia or nitric acid output being used for other purposes. Some of these processes depend upon the direct union of nitrogen with oxygen by gaseous explosion or under the influence of the electric arc (to which an extended surface is given) at a temperature of about 3,000° C., but this method can only be economically carried out where cheap and abundant supply of water-power is available for production of the requisite electric energy. (See *C.T.J.*, 1927, **81**, 29.) This process, therefore, can be regarded as practically obsolete.

In one modification of the process, oxygen and nitrogen are passed through the arc in about equal quantities, the yield being improved, however, by using an excess of oxygen, and it has been stated that instead of using ordinary atmospheric pressure, it is better to use a pressure of from 50 to 100 lbs. per square inch. Under these conditions

NITROGEN FIXATION (*Continued*)—

nitric oxide is first of all formed, then nitric peroxide, and at ordinary temperatures and in the presence of water this product is partially convertible into nitric acid, the equations being represented as follows:

$$N_2 + O_2 = 2NO,$$
$$2NO + O_2 = 2NO_2,$$
$$2NO_2 + H_2O = HNO_3 + HNO_2,$$
$$3HNO_2 = HNO_3 + 2NO + H_2O.$$

It is stated that about 80 per cent. of the nitrogen oxide gases can be absorbed in water (forming nitric acid containing about 33 to 35 per cent. HNO_3), and, subsequently, some 15 per cent. in soda lye, forming sodium nitrite, which can be obtained in the solid form by evaporation. The dilute nitric acid can be concentrated up to about 68 per cent. by distillation under ordinary atmospheric pressure, while by distillation with concentrated sulphuric acid or in contact with fused sodium bisulphate the strength can be brought up to over 90 per cent. (See B. F. Halvorsen (*C.T.J.*, 1924, **75**, 158), and for particulars respecting energy requirement and consumption, S. Karber (*Ibid.*, 1925, **77**, 391).)

In the "Häusser" process the heat caused by the explosion of a mixture of combustible gas (preferably coke-oven gas) and air is used to bring about the union of nitrogen and oxygen, oxides of nitrogen being produced which can be absorbed in water, whilst power is generated simultaneously. The nitrous gases are passed into vertical iron cylinders lined with acid-proof stone in which the nitric oxide is oxidized by atmospheric oxygen into nitric peroxide, the gases being finally condensed with water in washing towers and thus converted into nitric acid.

Nitric acid is also produced by the oxidation of ammonia, using catalytic agents, such as platinum gauze. In this process a mixture of air and ammonia containing about 10 per cent. of the latter, is passed through platinum gauze or other catalyst placed between washers of asbestos board or nickel-chrome sheet, heated in the first place by a plumber's blow-pipe or otherwise, but maintained subsequently at a cherry-red heat by the chemical change which is involved, most of the nitrogen being oxidized to nitric oxide, which upon cooling combines with more oxygen to form nitric dioxide, and this is absorbed in water, forming nitric acid.

The "Haber" process, which was in use in Germany before the Great War is based upon the direct union of nitrogen and hydrogen at a temperature of about 600° C., maintained by means of an electric coil and under a pressure of from 200 to 300 atmospheres, in the presence of a catalyst, thus producing ammonia, which can be subsequently converted either into nitric acid (by oxidation), ammonium nitrate, or ammonium sulphate. Metallic osmium serves well as a catalyst, but is too expensive for use on a manufacturing scale, and an activated iron catalyst such as ferro-molybdenum is employed in practice. It is stated that one plant at Höchst (Germany) is capable of producing the equivalent in nitric acid of 6,500 tons and another of 10,000 tons nitrate of sodium per month.

NITROGEN FIXATION (*Continued*)—

As now worked on the "Haber-Bosch" principle at Bellingham, the carbon monoxide of water-gas is made to react catalytically with steam so as to produce hydrogen. After compression and purification a mixture containing three volumes of hydrogen and one of nitrogen is made to produce ammonia by catalytic action at a relatively high temperature. The ammonia is dissolved in water and combines with a portion of the carbon dioxide (removed in the previous purification processes), and the ammonium carbonate thus produced is then made to react with anhydrite to produce ammonium sulphate and chalk. The chalk is utilized in making "nitro-chalk." The output of synthetic ammonia at Bellingham in 1930 was anticipated to amount to 200,000 tons per annum.

In the "Casale" process, as conducted in Italy, a pressure of from 700 to 850 atm. is used and the hydrogen is obtained electrolytically from large cells of a new type operated from hydro-electric currents obtained from great waterfalls. (See Hydrogen, p. 460.) Some of this hydrogen is burnt with air, and thereby the required mixture of hydrogen and nitrogen is produced.

In another modification of the process (more resembling the "Haber" process) the gases are sent over a catalyst at a pressure of 300 atmospheres, which facilitates partial liquefaction of the ammonia in anhydrous form, and the uncondensed ammonia is recovered by passage of the gases through a heat exchanger warmed by gases coming from the reaction chamber, etc.; an appropriate oxidation apparatus being used to remove the hydrogen as water, leaving almost pure nitrogen for use in synthesizing the ammonia.

In the "Claude" process, nitrogen boiled off from liquefied air is admixed with hydrogen gas in suitable proportions, and the mixed gases subjected as in the "Haber" process, but under a greatly increased pressure—viz., about 800 to 1,000 atmospheres, or nearly 6 tons per square inch, and at a temperature of 600° C.—so that whereas in the "Haber" process only about 13 per cent. of the gases is transformed into ammonia, 42 per cent. transformation is effected, and the product is obtained, owing to the great pressure, in liquid form. Per gramme of catalyst, the "Claude" process is stated to yield 6 grammes of ammonia against 0·5 produced by the "Haber" process, and it is reported that thirteen "Claude" plants produced *in toto* 54,250 tons of fixed nitrogen in 1925. (See G. Claude, *B.C.A.*, 1930, B, 710.)

By the "Mont Cenis" modified process, in which it is stated a new and very potent catalyst is used, a working pressure of below 100 atmospheres and a temperature not more than 400° C. suffice, coke-oven gas being employed as the source of the hydrogen which is specially purified.

The synthetic production of ammonia as carried out by the Union Chemique Belge is described in *Ind. Chem.*, 1929, v., 481 and 522.

Ammonia can be oxidized by air on the surface of a solid catalyst such as platinum wire gauze or ferric oxide at a temperature of about 650° to 700° C., the ratio of ammonia to air being from 1 : 7 to 1 : 9, the main reactions being represented as follows:

NITROGEN FIXATION (*Continued*)—

$$4NH_3 + 3O_2 = 2N_2 + 6H_2O,$$
$$4NH_3 + 5O_2 = 4NO + 6H_2O,$$

the nitric oxide thus produced being converted into nitric acid by means of atmospheric oxygen and water ($4NO + 3O_2 + 2H_2O = 4HNO_3$). For this purpose the gases issuing from the converter in which the nitric oxide is produced are cooled to about 30° C., and then passed into the oxidation and absorption towers. The temperature at which oxidation begins depends to some extent upon the form of the platinum catalyst—viz., about 145° for corrugated platinum foil, 170° for crumpled foil pellets, 240° for wire gauze, and 240° for wire in plug form—the yield of nitrogen oxides increasing with rising temperatures and being negligible above 900° C.

The "Serpek" process, which produces ammonia incidentally in the manufacture of alumina, is referred to under Aluminium (Oxide).

Another method for fixation of nitrogen aims at the direct production of alkali cyanides from nitrogen, an alkali and free carbon, the reaction being dependent (when soda is used) upon the intermediary reduction of sodium to the metallic state and iron being used as a catalysing agent ($Na_2CO_3 + 4C + N_2 = 2NaCN + 3CO$). It is stated that producer gas can be used instead of pure nitrogen gas.

It is reported that during the fertilizer year 1927-28 the world's production of fixed nitrogen products reckoned in terms of nitrogen itself amounted to 1·65 million tons (Rex Furness).

Other references: P. A. Guye (*J.S.C.I.*, 1906, p. 567); J. G. Thompson on "Plant for Nitrogen Fixation" (*C.T.J.*, 1926, **79**, 415; *Ibid.*, 1927, **80**, 228; *Ibid.*, 1928, **83**, 349; *Chem. and Ind.*, 1929, **48**, 591, and 1930, **49**, 1024); G. B. Taylor on "Catalytic Ammonia Oxidation" (*Ibid.*, November, 1926); G. P. Pollitt on the "Fixation of Nitrogen" (*J.S.C.I.*, 1927, **46**, 291 T), and on "The Synthetic Ammonia Industry" (*Ind. Chem.*, 1930, vi., 271); G. J. Fowler on the "Biochemistry of the Nitrogen Cycle" (*Chem. and Ind.*, 1929, **48**, 673); R. E. Slade on "The Nitrogen Industry and our Food Supply" (*Chem. and Ind.*, 1930, **49**, 760); Dupare, Wenger, and Urfer (*B.C.A.*, 1930, A, 1139; *C.T.J.*, 1930, **86**, 500); survey of the world's nitrogen position given in the report for 1930-31 of the British Sulphate of Ammonia Federation, Ltd. (*C.T.J.*, 1932, **90**, 100); books by J. Knox (Gurney and Jackson); Bruno Waeser, translated by E. Fyleman (J. and A. Churchill); and F. A. Ernst (Chapman and Hall, Ltd). (See also Nitroxan.)

NITROGEN TRICHLORIDE—See Nitrogen Compounds, p. 620.

NITROGENIZE—To combine nitrogen or nitrogenous groups with other substances.

NITROGENOUS—Substances containing nitrogen as an important constituent, such as urea, proteins, etc.

"NITRO-CHALK"—See p. 622.

NITRO-GLYCERINE—See Explosives.

NITRO-GLYCOL—See Explosives.

NITRO-GROUP (**Nitryl**)—The univalent group —NO_2, as present in nitrobenzene ($C_6H_5NO_2$), for example.

NITRO-HYDROCHLORIC ACID—See Aqua Regia.

NITRO-LIME or "**NITROLIM**"—See Cyanamide.

NITROMETER—A sort of eudiometer for measuring nitrogen gas evolved from such chemical interactions as occur between nitrates and sulphuric acid in the presence of mercury, and between ammonium salts and an alkaline solution of sodium hypobromite. An improved form is described by R. B. Foster (*Chem. and Ind.*, 1926, **45,** 54); see also Organic Analyses.

NITRO-NAPHTHALENE—See Naphthalene.

NITRO-PHENOL (*o*-, *m*-, **and** *p*- **Compounds**) ($C_6H_4OH.NO_2$)—Crystalline substances soluble in alcohol and ether, the *m*- compound being used for manufacturing the dyes known as "rhodamines" (which are closely allied to fluoresceïn), whilst the *p*- compound is used in making phenacetin, and for the antiseptic treatment of raw rubber, etc. The *o*- and *p*- nitro compounds result from mixing phenol with cold dilute nitric acid, the *o*- compound being obtained from the mixture by distillation. The *m*- compound is obtained by diazotizing *m*- nitraniline, and the *p*- compound by diazotizing sulphanilic acid and treatment of the diazo compound with warm dilute nitric acid. The *o*- compound is yellow, and melts at 45° C.; the *m*- compound is also yellow and melts at 96° C. whilst the *p*- compound is colourless, and melts at 114° C.

(For Trinitro-phenol see Explosives (Picric Acid).)

"**NITROPHOSKA**"—A German make of fertilizer resembling in certain respects another product known as "Leunaphoska," prepared in several grades for different soils, containing nitrogen, water-soluble phosphoric acid, and potash. It has been described as essentially a ternary mixture of potassium nitrate, ammonium chloride, and ammonium phosphate, made by adding potassium sulphate or chloride containing over 50 per cent. K_2O and di-ammonium phosphate or di-calcium phosphate to fused ammonium nitrate.

The nitrogen in both No. 1 and No. 2 qualities of "nitrophoska" is reported to be as one-third of the total content in the form of nitrate-nitrogen combined with potash, and the other two-thirds in the form of ammonia-nitrogen combined with phosphoric acid. The No. 2 contains more potash, and is recommended specially for light sandy soils.

NITROSAMINES—A series of yellow, aromatic, volatile bodies derived from the secondary bases (amines) containing the imino group $:NH$, by treatment with nitrous acid, such as dimethyl nitrosamine, $(CH_3)_2N.NO$. (See Hydrazine.)

NITROSO-BENZENE ($C_6H_5{\cdot}N:O$) is an aromatic, colourless compound, m.p. 68° C., with an odour resembling that of cyanic acid, produced by interaction between nitrosyl chloride ($No{\cdot}Cl$) and mercury di-

NITROSO-BENZENE (*Continued*)—
phenyl in benzene solution; or by oxidation of diazo-benzene with alkaline permanganate, or, alternatively, that of phenyl-hydroxylamine by means of chromic acid or ferric chloride.

It yields aniline by reduction and nitro-benzene by oxidation.

NITROSO COMPOUNDS contain the nitroso group —N : O—; for example, nitroso-benzene ($C_6H_5{\cdot}N:O$). The introduction of the group is styled *nitrosation*.

NITRO-STARCH—A nitrated preparation, made by nitrating starches with a mixture of sulphuric and nitric acids, and used in making safety explosives.

NITROSYL—The monovalent radical —N : O as it exists in a number of compounds, such as nitrosyl chloride (NOCl), an orange-coloured gas resulting from the direct combination of nitric oxide with chlorine.

NITRO-TOLUENE (Nitro-Toluol) ($CH_3.C_6H_4.NO_2$)—Produced by the nitration of toluene. The *p*- compound is a solid, crystalline yellow body which melts at 51° C., boils at 234° C., and is employed for making fuchsine and other dyes in common with the *o*- compound, which is a yellow liquid substance which boils at 218° C., and can be used in common with nitro-benzene in preparing so-called "oil of mirbane."

The *m*- compound is yellow and crystalline. All are heavier than water, and insoluble in it, but are soluble in alcohol and ether.

(For Trinitro-toluene see Explosives.)

NITROUS ACID—See Nitrogen Compounds.

NITROUS ETHER (Ethyl Nitrite or Sweet Spirit of Nitre) $C_2H_5(NO_2)$—The ester of nitrous acid; a yellowish, aromatic, volatile, and inflammable liquid of sp. gr. 0·900 and b.p. 16·4° C.; soluble in alcohol and ether; prepared by the action of nitric acid upon alcohol, and used as a diuretic and stimulant.

NITROUS OXIDE (Laughing Gas)—See Nitrogen Compounds.

"NITROXAN"—A catalyst for the direct oxidation of ammonia to nitric acid by air, compounded of meta-plumbate and manganese dioxide in equi-molecular proportions, heated together in air. The nitric acid is retained as barium nitrate in the catalyst mass. (See G. Kossner, *C.T.J.*, 1924, **75**, 330).

NITROXYL—The monovalent radical —NO_2 as it exists in compounds such as the colourless gas, nitroxyl fluoride (NO_2F), and copper nitroxyl (Cu_2NO_2).

NOMENCLATURE—The terms and names used to identify and classify chemical substances.

Certain rules adopted by the Nomenclature Committee of the Chemical Society of London and that of the American Chemical Society are as follows:

1. In naming a compound so as to indicate that oxygen is replaced by sulphur, the prefix *thio* and not *sulpho* should be used (sulpho denotes the group SO_3H); thus, HCNS, *thio*cyanic acid; H_3AsS_4,

NOMENCLATURE (*Continued*)—

*thio*arsenic acid; $Na_2S_2O_3$, sodium *thio*sulphate; $CS(NH_2)_2$, *thio*urea. The only use of *thio* as a name for sulphur replacing hydrogen is in cases in which the sulphur serves as a link in compounds not suitably named as mercapto derivatives; thus, $H_2NC_6H_4SC_6H_4NH_2$, thiobisaniline. *Hyposulphurous acid*, not hydrosulphurous acid, should be used to designate $H_2S_2O_4$.

2. The word *hydroxide* should be used for a compound with OH and *hydrate* for a compound with H_2O. Thus, barium hydroxide, $Ba(OH)_2$, chlorine hydrate, $Cl_2.10H_2O$.

3. Salts of chloroplatinic acid are *choroplatinates* (not platinochlorides). Similarly salts of chloroauric acid are to be called *chloroaurates*.

4. Hydroxyl derivatives of hydrocarbons are to be given names ending in *-ol*, as glycer*ol*, resorcin*ol*, pinac*ol* (not pinacone), mannit*ol* (not mannite), pyrocatech*ol* (not pyrocatechin).

5. The names of the groups NH_2, NHR, NR_2, NH, or NR should end in *-ido* only when they are substituents in an acid group, otherwise in *-ino;* thus, MeC(: NH)OEt, ethyl im*ido*acetate; $NH_2CH_2CH_2CO_2H$, β-am*ino*propionic acid (not am*ido*proprionic acid); $NHPhCH_2CH_2CO_2H$, β-anil*ino*propionic acid; $CH_3C(:NH)CO_2H$, α-iminopropionic acid.

6. Hydroxy-, not oxy-, should be used in designating the hydroxyl group; as *hydroxy*acetic acid, $CH_2(OH)CO_2H$, not *oxy*acetic acid. *Keto-* is to be preferred to *oxy-* to designate oxygen in the group —CO—.

7. The term *ether* is to be used in the usual modern acceptation only, and not as an equivalent of *ester*.

8. Salts of organic bases with hydrochloric acid should be called *hydrochlorides* (not hydrochlorates nor chlorhydrates). Similarly hydrobromide and hydriodide should be used. (See also *J.C.S.*, 1931, pp. 1607-1616; Atoms, Chemical Compounds, Chemical Interactions, Elements, Formulæ, and Rings.)

NOMOGRAMS (A J. Underwood)—

Capacity of Storage Boilers, *C.T.J.*, 1925, **77**, 325.

Power required for Pumping, *Ibid.*, 1925, **77**, 479.

Logarithmic Mean Temperature, *Ibid.*, 1926, **78**, 127.

Loss of Heat from Surfaces, *Ibid.*, 1926, **78**, 7.

Heat Transmission between Moving Liquid, *Ibid.*, 1926, **79**, 113.

Pressure and Stress in Centrifuges, *Ibid.*, 1926, **79**, 192.

Air Moisture in Drying Operations, *Ibid.*, 1926, **79**, 363.

Calculating Calorific Value of Gases (L. J. Rogers, *B.C.A.*, 1930, B, 890).

Nomogram for Converting Observed Volumes of Gas to Normal Temperature and Pressure (J. H. Coste, *Analyst*, 1929, **54**, 656); for Reduction of Gas Volumes to N.T.P. (G. Barr, *J.S.C.I.*, 1930, **49**, 21 T); for Technical Gas Analysis (E. S. von Bergkampf, *B.C.A.*, 1930, B, 443); for Gas Analysis (Methane and Hydrogen Contents) (J. Schmidt, *B.C.A.*, 1931, B, 523); Applications of Nomograms to Calculation of Gas Quantities (A. Boehm, *B.C.A.*, 1931, B, 93); Nomograms for Calculating Calorific Value of Coal from the Elementary Analysis (W. Schreiber, *B.C.A.*, 1932, B, 166).

NOMOGRAMS (*Continued*)—

Chemical Engineering Charts, No. 1—Drying Tunnels and Chambers (Steam Heated), *Ind. Chem.*, 1931, vii., 121.

No. 2—Influence of Variations in Air Temperature and Velocity on Rate of Evaporation, *Ibid.*, 1931, vii., 156.

No. 3—Resistance to Flow of Gas in Ring-filled Scrubbers and Absorption Towers, *Ibid.*, vii., 245.

No. 4—Steam Jacketed Copper Pans, *Ibid.*, vii., 374.

Chart from 1818-1908—General Commodities, *Chem. and Ind.*, 1931, **50,** Editorial, p. 333 and next p. 350.

See also O. Liesche, *B.C.A.*, 1929, B, 115; A, 1262, and 1931, B, 421; A. Sulfrian on Nomograms in Chemical Technology, *B.C.A.*, 1931, B, 421; *Industrial Chemical Calculations,* by O. A. Hougen (Chapman and Hall, Ltd.); and Data Sheets.

NOMOGRAPHS—Nomographic Method of Solution (A. Alison, *Ind. Chem.*, 1930, vi., 402). The Construction for the Solution of Formulæ, by A. Alison (*Ind. Chem.*, 1931, vii., 143, 183, 330, and 495).

NON-FERROUS METALLURGY—See Metallurgy and Ores.

"NON-OX"—An extremely subdivided powder of complex nature—probably of the aldehyde-amine type—of low sp. gr., advocated as an anti-ager. It increases the resistance to heat of rubber compounds, and prevention of "after cure" in accelerated products. It is sufficiently soluble in warm rubber to allow of easy compounding, but is not recommended for light, brightly coloured stocks, since, as ageing proceeds, there is a tendency for the rubber containing it to darken slightly.

NONYLENE—See Hydrocarbons.

NORDHAUSEN ACID—See Sulphur (Sulphuric Acid), p. 879.

"NORIT"—A proprietary, heterogeneous, amorphous form of carbon of vegetable origin, with high decolourizing and filtration powers, containing about 10 per cent. moisture, 5 to 7 per cent. ash, and the remainder carbon, said to be almost thirty times as efficient as bonechar.

NORMAL STANDARD SOLUTIONS—See Volumetric Analyses.

NORMAL TEMPERATURE and PRESSURE (N.T.P.)—0° C. and 760 mm.

NORPINIC ACID—See Pinene.

NOTATION—The use of symbols and formulæ to denote the constitution of chemical substances. (See Chemical Compounds, Chemical Interactions, and Elements.)

"NOVOCAINE" (or **=*p*-Amino-benzoyl-diethylamino-ethanol hydrochloride,** $NH_2.C_6H_4.CO.O.C_2H_4.N.(C_2H_5)_2HCl$)—A complex organic substance used as a local anæsthetic in place of cocaine, being less toxic.

"NOVOCRETE"—A form of concrete made from cement and chemically treated (mineralized) sawdust, the latter replacing the usual aggregate of sand or gravel; it is about one-half the weight of ordinary concrete, may be cut with a knife, receives nails readily, and is advocated for use as a building material, etc.

"NOVOLAK"—A phenol-formaldehyde resin. (See Pollak and Riesenfeld, *B.C.A.*, 1931, B, 212.)

"NOVO-TEXTIL"—A French wool-like variety of silk substitute.

"N.T." is the title of a new fibre the basis of which is a waste vegetable material so treated by a chemical process as to form a staple possessed of strength, elasticity, and softness, allowing of competition and co-operation with natural wool.

N.T.P.—Normal temperature and pressure. (See Normal T. and P.)

NUCLEIC ACID—A medicinal food product derived from yeast, credited with the formula $C_{38}H_{50}O_{49}N_{15}P_4$. (See Monograph by Levene and Bass (Amer. Chem. Soc. Chem. Catalog. Co., 1931).)

NUCLEINS (Nucleo-Proteins)—A group of albuminoid substances or proteins contained in many animal and vegetable tissues, such as pus cells, blood corpuscles, and yeast cells. They are insoluble in water, but soluble in alkalies, and contain phosphoric acid in combination. Upon hydrolysis they yield albumin and nucleic acid, and subsequently various bases such as adenine, hypoxanthine, etc.

"NUJOL"—A heavy paraffin oil of poor wetting power used in paint-making, and as a remedy for constipation.

"NULOMOLINE"—A proprietary article used as a substitute for glycerine in respect of certain applications, being a solution of partly inverted sugar of sp. gr. 1·4.

NUT GALLS—See Gall Nuts.

NUT OILS—There are many varieties, the more important being described under their several names. Palm kernels contain about 50 per cent. by weight of a white, solid fat, which, after refining, is used in making margarine and soap, and the residual cake or meal resulting from the crushing and extraction of the oil is a serviceable cattle food. Ground-nuts or earthnuts contain from about 35 to 40 per cent. of a liquid, palatable oil, and, when freed from the husks, about 45 per cent. of the (arachis) oil. The residual cake is highly albuminous, that from the decorticated seed sometimes testing above 50 per cent., and is much relished by cattle. Hazel nuts yield 60 per cent. of a pale yellow oil, and walnut oil, from the kernel of *Juglans regia*, is a quick-drying, green oil when freshly extracted; it turns yellow on keeping, is inodorous, and used in painting. Walnuts yield as much as from 50 to 65 per cent. of this oil, which forms a soft soap when saponified with potash. Almond nuts contain about 55 per cent. fat; beech nuts, 57 per cent.; brazil nuts, 66 per cent.; cocoa-nuts, from 50 to 55 per cent.; filberts, 65 per cent.; hickory nuts, 67 per cent.; pea-nuts, 39 per cent.; pistachio nuts, 51 per cent.; and pecan nuts, 70 per cent.

"Nut Oil" (Arachis Oil) should not be confounded with true walnut oil, which was wont to be described as "nut oil." (See Arachis Oil.)

NUTMEG OILS—The wild oil nutmegs (kernels contained within the aril or mace) of *Myristica fragrans* (N.O. Myristicaceæ), indigenous in the Moluccas, S. Asia, and abundant in South America, yield by expression about 26 per cent. of oil of mace of yellowish colour and sp. gr. 0·870

NUTMEG OILS (*Continued*)—

to 0·925 at 15° C., opt. rot. +10° to +30°, and ref. ind. of 1·475 to 1·484 at 25° C. It contains various fatty acids and resin, is soluble in alcohol, and used for soap and candle making, flavouring, and perfumery. By distillation it yields a colourless essential oil having the flavour of the nutmeg. The composition of nutmeg butter (*Myristica officinalis*) is given by Collin and Hilditch (*J.S.C.I.*, 1930, **49**, 142 T).

Nutmegs of various species are cultivated in Java, Sumatra, Singapore, the West Indies, Ceylon, etc., and are used as a condiment in cooking and in the preparation of mace.

The oil is stated to contain about 4 per cent. of a narcotic body named myristicin ($C_{12}H_{14}O_3$), together with some terpenes and alcohols.

The kernels of the Otoba nutmeg (*Myristica otaba*), from Colombia, are stated to yield 7·2 per cent. of a colourless, volatile oil, of sp. gr. 0·894, opt. rot. +79·55, and ref. ind. 1·502; soluble to the extent of 16 volumes in 90 per cent. alcohol at 15° C. (See Mace and Mace Oil.)

The oil from the seeds of *Nigella satira* is described by Bures and Mládková (*B.C.A.*, 1931, A, 1101).

NUTRITION—See Foods and Feeding Stuffs.

NUX VOMICA—The dried seeds or beans of a species (*Str. nux vomica*) of apocynaceous plants which grow in Ceylon and other parts of the East Indies and Northern Australia, and yield the two crystalline bases strychnine ($C_{21}H_{22}N_2O_2$) and brucine ($C_{23}H_{26}N_2O_44H_2O$) (a dimethoxy strychnine soluble in alcohol, and resembling strychnine in its physiological action). In anhydrous form brucine melts at 178° C. Strychnine is also obtained from the *Str. colubrina* tree (which grows in the Moluccas and yields so-called snake-wood) and from the *Str. S. Ignatii* and *S. Tieuté.* (See Strychnine.)

OAK BARK (from *Quercus robur,* etc.)—There are about 300 species of oak growing in the northern hemisphere, *Q. robur,* the common English oak, being the most widely distributed. (See Tannins and Gall Nuts.)

OAKUM—Hemp-rope fibre, used with tar or pitch for caulking purposes.

OBSIDIAN—A dark green or jet variety of lava, glass-like in character, containing oxides of aluminium, magnesium, potassium, sodium, and silica; used for making ornaments and varieties of glass. (See Pumice.)

"OBSIDIANITE"—A proprietary brand of fire and acid proof material. (See Tower-fillings.)

OCCLUSION—This term is used, chemically, in respect of the property exhibited by certain metals of absorbing or occluding gases when exposed to them in a heated condition. The behaviour of the metals platinum and palladium in this respect is referred to more particularly under those headings, and in a fine state of division, gold, iron, nickel, copper, aluminium, and lead will all absorb more or less hydrogen gas. Iron also occludes carbon monoxide, and melted silver is capable of occluding oxygen gas when in a molten condition.

OCCLUSION (*Continued*)—

Apart from the increase in volume, there is no change in the appearance of the metals, but their density is, of course, diminished proportionately, and the combinations are regarded by some as solid solutions.

In view of recent investigations concerning the activation of certain gases, atomic structure, and the ultimate nature of the chemical elements, it would seem of importance, as the author of this Encyclopædia suggested in 1912 (*Chem. News*, cvi., 183), to further study the gases absorbed by metals, in order to determine the differences in their physical or chemical qualifications from those originally exposed to their action. Studies in catalytic combustion by Bone and Andrew would make it appear that the oxidation of carbon monoxide by oxygen over surfaces of nickel, copper, and other oxides is independent of the oxidation of a primarily formed carbonyl film or the reduction of a metallic oxide, and probably only involves the activation by occlusion of the respective gases.

In the Faraday Lecture delivered by Theodore William Richards to the Chemical Society in 1911, it was pointed out that such porosity as occurs in rigid, compact solids usually permits the passage only of substances which enter into the chemical structure of the solids themselves. Thus, nitrogen cannot free itself from imprisonment within hot cupric oxide, although oxygen can escape; again, water cannot evaporate into even the driest of atmospheres from accidental incarceration in crystals lacking water of crystallization. Palladium, on occluding hydrogen, is obliged to expand its bulk in order to make room for even this small addition to its substance. The behaviour of platinum, nickel, and iron is probably analogous, although less marked. Fused quartz, impermeable when cold, allows of the passage of helium and hydrogen at high temperatures; but most other gases seem to be refused admission, and very many solid substances appear to act as effective barriers to the passage of even hydrogen and helium, especially when cold. He concludes, from a review of the available evidence, that interstices between atoms in solids and liquids must be extremely small in proportion to the size of the atoms themselves, while he raises the question if there are any interstices at all (see Ether (Æther) and Porosity). He believes that atoms are compressible throughout their whole substance—*i.e.*, they may contract or expand, or vibrate within themselves, even when they are so closely packed together as to prevent their surfaces from moving.

For occlusion in the sense of adsorption, see Colloid Chemistry; also K. Iwasé (*B.C.A.*, 1927, A, 15); E. Martin (*B.C.A.*, 1930, B, 194); Hydrogen (p. 459), Nascent, Nitrogen (p. 611), and Porosity.

OCCUPATIONAL MATTERS—The Blue Book of Industry Tables, issued some years since by the Ministry of Health (H.M. Stationery Office), gave 17,178,050 as the number of persons over twelve years of age engaged in industry in England and Wales, and the following figures are those of the total then employed in the specified industries and the numbers of professional men engaged per 1,000 in each :

OCCUPATIONAL MATTERS (*Continued*)—

Industry.	Number Employed.	Professional.
Mining, quarrying, and products treatment	1,283,728	2
Bricks, pottery, and glass	176,541	2
Chemicals, dyes, and explosives	197,677	23
Metals, machines, conveyances, and jewelry	2,196,014	4
Textiles and cellulose	1,153,829	2
Leather industry (not boots, etc.)	80,472	1
Gas, water, and electricity	162,767	8

There were, according to a statement made by Sir Thomas Legge (when Chief Medical Inspector of Factories), 139,920 factories and 140,850 workshops in England, Scotland, and Wales at the beginning of 1924. An issue of the *Board of Trade Journal* in 1928 states that the number of persons employed in industry had risen from 6,687,500 in 1907 to 7,612,800 in 1924, of which last number 5,746,100 were males and 1,866,700 were females. These figures are exclusive of out-workers numbering 97,000 in 1907 and 44,000 in 1924. It was estimated that altogether 20,000,000 were occupied in gainful occupations in 1924 as against 17,500,000 in 1907. See also K. Goadby on "Wearing Gloves and Dermatitis" (*The Times*, February 4, 1932); J. C. Bridge (*The Times*, February 13, 1932); and "Dictionary of Occupational Terms" (H.M. Stationery Office).

OCEANIUM (Hafnium)—Suggested name for a new element, said to be obtained in oxide form from the black magnetic ironsand of Taranaki (New Zealand), accompanied by titanium dioxide. (See Hafnium.)

OCHRES—A name given to a large number of natural pigments of clay or mixtures of clay with metallic oxides—yellow, red, and brown—some of which are found naturally in a more or less pulverulent form, such as iron or red ochre, and molybdic ochre. "Yellow ochre" is a clay coloured with ferric oxide, which reddens on being burned. Some ochres contain from 20 to 25 per cent. ferric oxide (Fe_2O_3), 50 to 60 per cent. silica (SiO_2), and 10 to 15 per cent. alumina (Al_2O_3), together with some water. They are used in paper-making and in the oilcloth, linoleum, paint, and varnish manufactures. (See *C.T.J.*, 1932, **90,** 82; Bole, Iron-oxide Pigments (p. 502), Umber, and Venetian Red.)

"OCTET" THEORY concerning Atomic Structure—See J. J. Thomson (*Phil. Mag.*, 1923 (vi.), **46,** 497; A, ii., 682); J. D. Main Smith (*J.C.S.*, 1927, p. 2029); and Valencies (p. 946).

OCTYL ALCOHOL ($C_8H_{18}O$ or $CH_3(CH_2)_7OH$)—See Alcohols.

OCTYLENE—See Hydrocarbons.

ODOUR THEORY (Olfaction)—The so-called "residual affinity" theory of the cause of odour rests upon the view that it arises from the free or unsatisfied affinity of constituent molecules.

To have an odour, a substance must possess this residual or unsatisfied affinity, be volatile, sufficiently soluble in the water and the lipoid fats of the nose, and give chemical reaction with osmoceptors in

ODOUR THEORY (*Continued*)—

the nose. (See J. Missenden (*Analyst*, 1926, **51,** 203); J. H. Kennet on "Odours and the Sense of Smell" (*Nature*, 1926, **117,** 591); T. H. Fairbrother (*Ind. Chem.*, 1926, ii., 385); and W. Doran on "Odour and Chemical Constitution" (*Chem. and Ind.*, 1930, **49,** 235).

Unsaturated bodies, generally, have distinctly stronger odours than saturated ones. (See Capsicum.)

ŒNANTHIC ACID—See Heptoic Acid.

ŒNANTHIC ETHER (**Cognac Oil**) ($C_9H_{18}O_2$)—A mobile liquid substance used in the preparation of artificial cognac and for flavouring wines; made from œnanthic acid (heptoic or heptylic acid) and ethyl alcohol by the action of sulphuric acid, and prepared commercially from the oxidized products of oil of rue. It is also described as a mixture of ethers (chiefly ethyl caprate), has a strong vinous odour, and is readily soluble in alcohol and ether. Many fusel oils contain capric and caprylic acids, and some Hungarian wines are known to contain amyl caprate.

Another variety of cognac oil is stated to be made by the distillation of castor oil, consisting, as is reported, of a mixture of œnanthaldehyde and undecylene. The residue left after distillation, named "floricin," is used to increase the viscosity of mineral oils, etc.

ŒNANTHOL [**Normal Heptylic Aldehyde** ($C_7H_{14}O$)]—Prepared by the dry distillation of castor oil under reduced pressure; a volatile, colourless liquid of sp. gr. 0·850, boiling at 153° C.

OHM—See Electricity, p. 298.

"OHMAL"—An improved resistance alloy of the manganin type.

OIL CAKES—The cakes remaining after the expression or extraction of oils from seeds, used as cattle foods and fertilizers. When pressure alone is used more oil is left in the cakes than by the extraction process following upon the use of pressure, so that they are more valuable for feeding sheep and cattle. Better results are obtained when the pressure method is used by first of all heating the seed so as to coagulate the albuminous contents, thus effecting better liberation of the oil. The output is very large, Liverpool alone producing some 10,000 to 15,000 tons weekly.

Statistics regarding the seed-crushing trade taken from the *Board of Trade Journal* are reproduced in the *C.T.J.*, 1927, **80,** 374, and *Chem. and Ind.*, 1927, **46,** 342. See also Oils, p. 636.

Home-Manufactured Cakes and Meals—Linseed cake containing not less than 8 per cent. oil, cotton-seed cake, undecorticated groundnut cake, semi-decorticated ground-nut cake, decorticated ground-nut cake, palm-kernel cake, rape cake, copra cake, sesame cake, soya cake, extracted palm-kernel meal, extracted rape meal, extracted soya meal.

Imported Cakes and Meals—North American linseed cake, Argentine linseed cake, Canadian linseed cake, Australian linseed cake, Spanish and Portuguese linseed cake, Egyptian cotton-seed cake, decorticated cotton-seed meal, decorticated cotton-seed cake, re-pressed cotton cake,

OIL CAKES (*Continued*)—

semi-decorticated cotton cake, copra cake, palm-kernel cake, Rangoon rice meal, Italian rice meal, Canadian rice meal, Egyptian rice meal, gluten feed, maize-meal cake.

The feeding values of cakes are chiefly represented by their protein and oil constituents. Mustard, castor oil, undecorticated cotton-seed cake, and others are chiefly used as fertilizers. (See Feeding Stuffs and Oils.)

OILCLOTH—This material consists of some suitable fabric such as canvas coated with a mixture of linseed oil, whiting (or other equivalent body material), and pigment, with or without a pattern printed on the surface. (See Linoleum.)

"OILDAG"—See Lubricants.

OIL FUELS—See Fuel (Liquid) and Petroleum.

OIL OF VITRIOL—See Sulphur (Sulphuric Acid).

OILS—There are oils of many kinds, but they may be roughly divided into three classes—viz., the essential oils, which are generally described under that heading and more particularly under their individual names, and are for the most part hydrocarbons; the petroleum and paraffin class, derived from natural deposits or distillation of coal, lignite, wood, peat, etc., which are also hydrocarbons, but of another class (see Petroleum); and fats or fixed oils, derived from animals, vegetables, or fishes, which are obtained either by pressing the nuts, seeds, or organs of the fishes which contain them, or extracting them with solvents, the more important of which are also described under their several names. The general view is that in oil-seeds the oil forms an emulsion inside the cytoplasm; others assert that the cytoplasm is emulsified with the oil.

The following figures are taken from tables given by J. Van B. Gilmour (*Analyst*, 1925, **50,** 119-126):

Oil or Fat.	Melting-points of Insoluble Volatile Acids. Degrees C.	Melting-points of Fatty Acids. Degrees C.	Melting.points of Fat. Degrees C.	Iodine Values of the Insoluble Volatile Acids.
Arachis	32·1	32·0	Liquid at ordinary temperature	82·3
Cotton	33·0	34·9	,,	71·1
Sesame	31·8	23·5	,,	—
Whale	27·2	24·0	,,	—
Rape	13·5	19·2	,,	—
Palm	46·4	44·2	37·5	—
Oleo	40·0	41·9	35·7	—
Jus	41·8	46·8	48·1	—
Stearine (beef) ...	43·2	48·6	53·1	—
Lard	45·8	41·9	41·3	—
Hardened aracish	57·2	61·4	61·7	—
,, whale (1)	36·0	38·2	41·2	—
,, ,, (2)	37·3	42·7	44·0	—
,, ,, (3)	48·2	54·5	53·5	—
Coconut	—	—	—	1·2
Palm kernel ...	—	—	—	1·9

OILS (*Continued*)—

Approximate Typical Values (Constants) of Some Oils, Fats, and Waxes

Name	Sp. Gr. at 15° C.	Saponification Value.	Iodine Value.	Refractive Index.	Melting-point. Degrees C.	Solidifying-point. Degrees C.
Almond (sweet)	0·915–0·920	190–192	93–97	1·455 at 60° C.	about −10°	−10°–21°
Arachis (nut oil)	0·916–0·925	185–196	85·2	1·4612 at 40° C.	about −8°	0°–±2°
Argemone oil ...	0·9220	192·7	123·7	—	—	—
Bayberry (myrtle) wax	0·97–0·99	208·7	—	1·4363 at 80° C.	40°–44°	—
Beeswax ...	0·96–0·97	90–98	7·9–12·4	1·4439–W_{D}^{75}	60·5°–64°	—
Bone fat ...	0·9009–0·9034 at 50°/30°	189·6–195·2	49·1–51·6	—	44°–45°	32·6°–33·8°
Butter ...	0·926–0·940	220–233	26–38	1·4650 at 60°	—	—
Cacao butter ...	0·950–0·970	192–198	3·4–3·8	—	32°–34°	—
Candelilla wax	0·983–1·00	46–65	37	1·4555 at 71·5° C.	64°–67°	—
Candle-nut oil	0·925–0·927	190–214	136–140	—	18°	—
Carnauba wax	0·995	—	13	—	83°–91°	80°–81°
Castanha oil ...	0·918	193·5	106·22	—	0·4°	—
Castor ...	0·969	183–186	82–86	1·480 at 15° C.	13°	−10°–−18°
Ceresine wax ...	0·92–0·94	—	—	—	74°–80°	—
Chia oil ...	0·9338	192·2	192·2	—	—	—
Cockle-burr oil	0·9251	190·2	140·8	—	—	—
Cocoa-nut oil ...	0·925	233–253	7–10	1·4488 at 40° C.	26°–28°	22°
Cod-liver ...	0·92–0·93	187–197·5	150–181	1·479–1·483 at 15° C.	21°–25°	0°–10°
Cohune ...	0·868	252	11–13·7	—	18°–20°	—
Cotton-seed ...	0·922–0·927	193–195	105	1·4643 at 40° C.	35°–38°	—
Chinese wax (Pela) ...	0·970	80–93	1·4	—	80°–83°	—
Cucumber ...	0·923	188·7	121	—	—	—
Dika butter ...	0·914 at 40°	244·5	5·2	—	38·9°	—
Dugong oil ...	0·92–0·93	204·7	52·5	—	—	—
Ghedda wax ...	—	—	—	—	55°–56°	—
Goat's butter ...	0·9169–0·9346 at 38°	—	24·73–34·84	1·4541–1·4559	—	—
Goose fat ...	—	192·6	72·77	—	29°–31°	—
Grape-seed oil	0·92–0·935	178–180	94–96·5	1·4713 at 25° C.	24°	−10°–−13°
Hazel-nut oil ...	0·9152–0·9156	190	84–85	—	—	—
Hempseed ...	0·925–0·928	192–193	141–148	1·448 at 15° C.	18°–19°	−27°
Herring ...	0·92–0·932	180–194	139–142	1·478	—	—
Hibiscus oil ...	0·9091	189·2	89·7	—	—	—
Hongay oil ...	0·9273–0·9385	185·7	85·6–88·9	—	—	—
Illipe-nut oil (Singapore)	0·9021 at 40°/4° C.	188·4	50–64	—	39°–40°	—
Japanese wax (vegetable) ...	0·97–0·98	217–237	5·9	—	53°	—
Lard (hog) ...	0·935	195·4	—	1·4539 at 60°	41·3	—
Lard oil (cold pressed) ...	0·915	195	56–74	—	—	—
Lime-seed oil ...	0·9236	197·7	109·5	1·4635 at 40°	—	—
Linseed oil ...	0·927–0·932	188–195	170–190	1·4725 at 15° C.	17°–21°	−27°
Macassar oil ...	0·86 at 99°/15° C.	214·4–229·1	52·4–55	—	21°	—

N.B.—For information as to their oil or fat contents, etc., readers are referred to the descriptions of these products in the text, and are reminded that the values given on this and following page are approximate only, many different figures being recorded for some of them.

OILS (*Continued*)—

APPROXIMATE TYPICAL VALUES (CONSTANTS) OF SOME OILS, FATS, AND WAXES (*Continued*)—

Name.	Sp. Gr. at 15° C.	Saponification Value.	Iodine Value.	Refractive Index.	Melting-point, Degrees C.	Solidfying-point. Degrees C.
Maize ...	0·9105	187·3	117·2	1·4768 at 15·5° C.	28°–29°	–10°––20°
Menhaden ...	0·927–0·933	191–196	142–180	1·480 at 15° C.	—	–4°
Montan wax ...	—	82·8	—	—	80°	—
Moura oil ...	0·894–0·898	190	60	—	23°–29°	—
Murumuru butter ...	0·914–0·918	240–241·5	11·2–11·5	—	34°–35°	—
Neat's-foot oil	0·92	194–199	58–70	1·469 at 20° C.	—	—
Ocuba wax ...	0·92	—	—	—	39·4°	—
Olive oil ...	0·916–0·918	185–196	79–90	1·4698 at 15° C.	24°–27°	–6°–+2°
Ozokerite wax	0·85–0·95	—	—	—	65°–80°	—
Palm oil* ...	0·865–0·873	196–205	10·7–83·5	1·4503 at 40° C.	23°–30°	31°–39°
Paraffin wax ...	0·880–0·915	—	—	—	60°–65°	—
Pilchard oil ...	0·9328–0·9313	186–189·6	170·4–172·7	1·4751/4	—	—
Pili-nut oil ...	0·9069 at –30°/4°	197·4	55·9	—	—	—
Poppy-seed oil	0·925–0·926	193–195	133–143	1·457 at 60° C.	–18°	–18°
Porpoise ...	0·926	195–256	88–119	1·468	—	–16°
Punna oil ...	—	187	102	—	—	—
Rape-seed ...	0·913–0·916	170–179	94–104	1·472–1·475	17°–22°	–2°–10°
Raphia wax ...	0·834	51	7·7–10·7	—	82·5°	—
Rubber-seed oil	0·925–0·93	188·5–192	128·3–143·3	—	—	—
Salmon oil ...	0·9258	182–188	161–190	1·478 at 20° C.	—	—
Sardine oil ...	0·93	189·0	158–190	1·4802–1·4808	28°–36°	—
Seal	0·924–0·926	189–196	127–193	1·474	22°–33°	–2°–3°
Sesame	0·921–0·925	188–193	103–114	1·473 at 15° C.	26°–32°	–5°
Shark	0·9248	188	154–172	1·476 at 25° C.	—	—
Shea butter ...	0·9175	179–192	56·6	—	45°	—
Soya bean ...	0·920–0·926	185–195	128–135	1·4673 at 40° C.	28°	–8°
Sugar-cane wax	0·961	168–177	60	—	55°–62°	—
Sperm (whale) oil	0·871–0·878	122–144	60–93	1·46 at 25° C.	—	—
Spermaceti ...	0·945–0·960	123–135	3·5–6·7	—	44°–47·5°	—
Sunflower ...	0·924	189–193	129–132	1·461 at 60° C.	—	–16°
Tallow (beef) ...	0·943–0·952	193–200	38–46	1·451 at 60° C.	41·2°–52°	—
,, (mutton)	0·937–0·953	192–195	35–46	—		—
Tea-seed oil ...	0·873	210	160	1·471	—	—
Tobacco-seed oil (Dalmatian)	0·925	196·4	131·6	—	—	—
Tobacco-seed oil (Kentucky) ...	9·9404	196	132·8	—	—	—
Tôhaku oil ...	0·9329	263·8	70·82	—	—	–14·4°
Tuna	—	—	156	—	—	—
Tung	0·936–0·943	190–195	150–176	1·503–1·518 at 20° C.	47°	–3°
Walnut	0·92–0·93	192–197	142–146	1·4808 at 20° C.	—	–27·5°
Whale (Balœna)	0·908–0·925	188–196	114–126	1·465 at 40° C.	23°–29°	—
Wool wax ...	0·94	102	25	1·48	35°	—

* Varying figures. (See Palm Oil.)

OILS (*Continued*)—

The fish oils are dealt with in another section. (See Fish Oils.)

It is on record that most vegetable and animal oils, in common with rape (colza) oil, yield petroleum oil when heated with anhydrous zinc chloride. Rape oil, by this treatment, gives a mixture of paraffins and olefines boiling at 60° to 310° C.

The fatty or fixed oils are all greasy in character, and can be made into soaps by saponification. By one process of extraction the crushed seeds are subjected to dry heat and agitation, whereby all moisture is driven off and the meal is converted into a sloppy state, and then centrifugalized at the same temperature. In this way 50 to 75 per cent. of the oil content can be extracted, so that only half of the usual pressing or other plant is required to complete the extraction.

Solvent extraction presents advantages over "pressing," and it is stated that, when properly conducted, using gasoline, for example, there is a loss of only 0·7 per cent. solvent based upon the weight of the raw material, and still less when using trichlorethylene.

A plant for the extraction of oils from seeds by solvents is described by L. J. Simon and J. N. Hinchley (*J.S.C.I.*, 1926, **45,** 252 T), and the "Solvent Extraction of Vegetable Oils" is dealt with by A. H. Amery (*Chem and Ind.,* 1930, **49,** 300) and A. E. Williams (*Ind. Chem.*, 1931, vii., 161). In practice, the pressing and extracting processes are often combined, and the residual meals find use as cattle food. (See Oil Cakes.)

The fatty or fixed oils are roughly divisible into two classes known as drying and non-drying. The former, such as linseed, hemp, and poppy oils, readily absorb oxygen from the air, thus forming a skin and gradually dry up, whilst the latter class (including almond, olive, and castor oils) do not so pronouncedly dry up in this way. From experiments of Eibner and Pallauf, it is inferred that the auto-catalytic agent is the aldehyde peroxide primarily formed (*J.C.S.*, 1925, Abstracts, I., 777), and there are reasons for regarding the product known as linoxyn to be represented by the composition $C_{57}H_{96}O_{20}$. The chemistry of drying oils is further referred to under the heading of Linseed Oil.

The oxidation of drying oils is accompanied by colloidal solidification and gel formation. "Blown oils" are made from semi-drying ones, such as rape-seed, maize, and cotton-seed, by blowing air through them at from 100° to 180° C., and "boiled oils" are made from linseed and other drying oils by heating them with a small proportion of some drier, such as manganese oxide or lead oxide. The oxidation products of drying oils is dealt with in a paper by Morrell and Marks (*J.S.C.I.*, 1931, **50,** 27 T), and the effect of blowing on the composition and viscosity of certain fatty oils is described by C. H. Thomson (*Analyst,* 1926, **51,** 177; see also Varnishes).

Vegetable oils undergo polymerization upon heating, and with the exception of linseed oil, they are said to be of low vitamin A value as compared with the chief animal oils. They have been found suitable for use as fuel in semi-Diesel engines; palm oil, cotton-seed oil, and

OILS (*Continued*)—

castor oil having been tested with good results, castor oil offering special advantages, being excellent both as fuel and lubricant.

The refining of edible oils by neutralization with caustic soda, deodorization and bleaching, is stated to be surpassed by a system of continuous distillation with steam *in vacuo* following bleaching, whereby the free fatty acids and odoriferous matters are removed in one operation, giving direct continuous production of a high-grade edible oil and a by-product acid oil. (See *C.T.J.*, 1928, **83**, 436.)

The oxidation of fatty oils at ordinary temperatures and at 120° C. leads to what is known as intramolecular polymerization, and at from 200° to 300° C. the polymerization is described as bimolecular. A fish oil, blown at 230° C. for seven hours, is reported to have attained a molecular weight of 1,200 as compared with an original one of 784.

Light has an important bearing upon polymerization of fatty oils, particularly the ultra-violet rays. Polymerization is most easily observed with highly unsaturated oils, such as tung and linseed oils, but is not altogether peculiar to them. It is shown by gelatinization and by increase in density, viscosity, and mean molecular weight, together with a decrease in the iodine value.

A new consistometer and its application to greases and oils is described by Bulkley and Bitner (*B.C.A.*, 1930, B, 674). It depends for its action on the measurement of flow through a capillary tube under a variable pressure head of mercury.

For definitions of saponification, iodine, and other values of oils and fats see Fats.

References: "Fatty Acids of Seed Oils," by Hilditch (with others) (*J.S.C.I.*, 1927, **46**, 457, 462, and 467 T); "Insulating (Transformer) Oils," by C. O. Harvey (*Chem. and Ind.*, 1927, **46**, 904); "Vegetable Oil Supplies," by E. T. Webb (*C.T.J.*, 1926, **79**, 97); "Some New Criterions for Fats and Oils," by H. P. Kaufmann (*B.C.A.*, 1926, B, 165); "Some New Aspects of their Chemistry," by J. C. Drummond (*Chem. and Ind.*, 1926, **45**, 994); "Oil Refining," by T. Andrews (*Chem. and Ind.*, 1926, **45**, 970); "Refining of Fatty Oils," by H. M. Langton (*Ind. Chem.*, 1927, iii., 483); "Steam Deodorisation of Saponifiable Edible Oils," by W. Brash (*J.S.C.I.*, 1926, **45**, 73 T); "Bleaching, etc., of Fatty Oils," by H. M. Langton (*Ind. Chem.*, 1928, iv., 26); "Viscosity Oils," by De H. Brückner (*C.T.J.*, 1928, **83**, 161); "Fatty Acids of some Indian Seed Oils," by Dhingra and Hilditch (*J.S.C.I.*, 1931, **50**, 9 T); "Oil Extraction Industry," by T. Andrews (*C.T.J.*, 1927, **81**, 465); "Oil-Mill Plant," by T. Andrews (*Ibid.*, 1927, **81**, 518 and 557); reviews of "The Oils, Fats, and Soap Industries in 1928, 1929, 1930, and 1931," by Rex Furness (*Ind. Chem.*, 1929, v., 15; 1930, vi., 22; 1931, vii., 13; and 1932, viii., 20); "Cold-Test" for Oils, by K. Rietz (*B.C.A.*, 1932, B, 116); "Vegetable Oils Output" (*C.T.J.*, 1932, **90**, 209); *Allen's Commercial Organic Analysis*, fifth edition, vol. ii. (J. and A. Churchill); Lewkowitsch's work on *Oils, Fats, and Waxes* (Macmillan and Co.); *Oil Industries*, by J. S. Southcombe (Constable and Co., Ltd.); *The Chemistry of Drying Oils*, by R. S.

OILS (*Continued*)—

Morrell and H. R. Wood (E. Benn, Ltd.); *The Oils and Fats Industry,* by T. P. Hilditch (Baillière, Tindall and Cox); and *Edible Oils and Fats,* by G. D. Elsdon (E. Benn, Ltd.). (See also Essential Oils, Fats, Fish Oils, Glycerides, Nut Oils, Oil Cakes, Petroleum, and Twitchell Process.)

OILS (**Hydrogenation of**)—It has been reported that cotton-seed, linseed, ground-nut, mohua (*Bassia latifolia*), sesame, and sardine oils, after refining and hydrogenating at 180° C., using nickel catalysts, have a practically identical refractive index value at 60° C. of 1·4468. The refractive index of hardened cocoa-nut oil is much lower than that of other oils with the same iodine value.

During the hydrogenation of oils an isomer of oleic acid is produced, and its presence in any quantity in edible fats is proof of the presence of hydrogenated oils; it appears to consist mainly of elaïdic acid, and has an iodine value of 90. (See Oleic Acid.)

These hydrogenated products can be used in many ways, as, for example, in making chocolate fats, margarine, soaps, candles, and leather dressing. According to S. Cleno (with others) the nutritive value of certain oils is increased by hydrogenation. (See *Analyst,* 1928, **53,** 443.) The hardened castor oil finds use as an insulating material for electrical purposes, and treated cotton-seed oil for giving a matte finish to paint compositions. (See *C.T.J.*, 1927, **81,** 495; Bergenization, Coal (p. 212), Hydrogenation (p. 461), and Motor Spirit.)

"OKOL"—A powerful fluid disinfectant, insecticide, and larvicide, consisting of an emulsion of phenoloids, including xylenols; miscible with water, and of special value as a destructive agent of malarial carriers.

OLEFIANT GAS (**Ethylene**) (C_2H_4)—See Hydrocarbons, p. 454.

OLEFINES (**Olefins**)—See Wheeler and Wood on "The Mechanism of Thermal Decomposition of the Normal Olefins" (*J.C.S.*, 1930, p. 1819) and Hydrocarbons, p. 454.

OLEIC ACID ($C_{18}H_{34}O_2$) in combination with glycerine (as olein) is contained in most fats and fixed oils, particularly the latter, and when pure is a tasteless, odourless, crystalline body, of sp. gr. 0·8908 and m.p. 14° C.; it is very soluble in alcohol and ether, and finds application in the textile industries and the preparation of polishing compounds. In a pure state it does not absorb oxygen from the air. Upon saponification with alkalies it yields combinations in the nature of soft soap. The natural oils containing olein belong to the "non-drying" class—that is to say, they do not thicken—*i.e.*, more or less dry up upon exposure to the air. (See S. H. Bertram, *B.C.A.*, 1927, A, 750.)

Oleic acid of about 93 per cent. strength, when treated with sulphuric acid, gives rise, after the product of the first reaction is treated with water, to hydroxy-stearic acid, melting at 85° C., into which product it can be nearly perfectly converted by a process of oxidation (Lapworth and Mottram, *J.C.S.*, 1925, cxxvii., I., 1628). J. H. Skellon has determined, among other characteristics of highly purified oleic acid, a

OLEIC ACID (*Continued*)—

setting-point of 11·8° to 12·2°, m.p. 13° to 14° C., ref. ind. 1·4610 and i.v. 90·1 (*J.S.C.I.*, 1931, **50,** 131 T).

Commercial oleic acid is sometimes described as "Red Oil."

Elaïdic Acid is a white, crystalline, stereoisomeric form of oleic acid ($C_{18}H_{34}O_2$), m.p. 45°, obtained by the action of nitrous acid upon that substance at 200° C. in the presence of sulphurous acid or sodium bisulphite.

OLEIN (**Oleine**) [$(C_3H_5)O.CO.(C_{15}H_{33})_3$]—The glyceride of oleic acid, being an oily body found present in many natural fats (particularly olive oil), and which yields stearin by hydrogenation, and oleic acid and glycerine upon hydrolysis. Commercial olein should be clear above 10° C., is easily emulsified by alkalies, free from unsaponifiable matter and neutral fat, of normal odour, and free from dirt and whale oil. (See A. Rayner (*C.T.J.*, 1928, **83,** 183, 205, and 289), Fats, and Oils.)

OLEINES—See Turkey Red Oil and Sulphonated Oils.

"OLEO"—The oil which, together with stearin, is obtained by pressing premier jus—that is, the fat expressed from beef at 48° C.—through filter-cloths. The stearin is used in making margarine, etc.

OLEOFRACTOMETER (**Jean's**)—An instrument for comparing the refractive powers of butter, fats, oils, glycerine, turpentine, etc., with standards.

OLEO-MARGARINE—Another name for margarine.

OLEOMETER—A form of densimeter for taking the specific gravities of oils.

OLEOPTENES—See Stearoptenes.

OLEO-RESINS—See Balsams and Gums and Resins.

"OLEOSOL"—See Lubricants.

OLEUM—See Sulphur (Sulphuric Acid).

OLIBANUM (**Frankincense**)—See Frankincense and Gums and Resins.

OLIVE OIL—An oil expressed (40 to 60 per cent.) from the fruit of the thornless olive-tree (*Olea Europeæ culta*, L., N.O. Oleaceæ), extensively grown in Spain, Italy, Greece, Turkey, and other countries of Southern Europe, Asia, and the Western States of America below latitude 35°. It is of great value as a food, and used also for the manufacture of cosmetics, pomades, "castile" and other kinds of soaps, also in respect of a great variety of commercial applications. The total world's production is estimated at about 1,000,000 tons, Spain, Italy, and Greece being the chief contributors.

Other species of *Olea* are more noted for their wood than for their oil.

The oil is mainly obtained by direct pressure of the crushed fruit, and from the pulp the remaining quantity is obtained either by steaming with hot water or by extraction with carbon disulphide or ethylene trichloride. There are a number of grades, the pure oil being of a pale yellow or greenish-yellow colour and agreeable taste; it solidifies at −6° to 2° C., sp. gr. 0·915 to 0·918 at 15·5° C., sap. v. 188

OLIVE OIL (*Continued*)—

to 197, i.v. 79 to 89, and ref. ind. 1·4605 to 1·4635 at 40° C. It contains about 84·2 per cent. of olein, 4·88 per cent. linolein, and 10·92 per cent. glycerides of saturated acids. An analysis of a Spanish olive oil is given by Tänfell and Sarria (*B.C.A.*, 1926, B, 332). Good olive oils have acid values ranging from 1·02 to 1·22.

When carbon disulphide is used for its extraction from the pressed residue ("orujo"), which still contains from 7 to 15 per cent. oil, it is not possible to remove all traces of sulphur from the product designated "sulphur olive oil," and this is used for soap-making.

"Gallipoli oil" is a crude olive oil used in the combing process of the textile trades. (See Turkey Red Oils.) The cake residue is used as a fertilizer and as fuel.

All pure virgin olive oils exhibit a yellow fluorescence under ultra-violet light. (See A. L. Glanz, *Analyst*, 1930, **55**, 773.)

It has been ascertained that when olive oil is heated with mannitol in the presence of a small amount of sodium ethylate, the glycerol can be replaced by it, and the product is far superior in all respects to the original olive oil as a food fat. (See Mannitol.)

An account of olive oil production in Tunis is given in *B.C.A.*, 1926, B, 953; see also J. Bonnet (*B.C.A.*, 1929, B, 136); a description of the Spanish industry (*Ind. Chem.*, 1930, vi., 109); and an account of the Italian industry (*C.T.J.*, 1932, **90**, 254).

OLIVE KERNEL OIL, from the kernels of olives, is yellowish or green, of sp. gr. 0·918 to 0·920, sap. v. 182 to 184, and i.v. 87; soluble in ether, chloroform, and carbon disulphide, and used for soap-making, as a culinary article, lubricant, and fuel.

OLIVENITE—A native arsenate of copper ($4CuO.As_2O_5 + H_2O$), of crystal system, No. 4, and sp. gr. 4·13 to 4·38, found in Cornwall and elsewhere; generally green in colour, but sometimes brown or yellow.

OLIVINE—A native variety of *chrysolite,* consisting of magnesium silicate with varying amounts of ferrous silicate [$(MgFe)_2SiO_4$].

"OLMINAL"—Trade name for aluminium oleate.

"ONAZOTE"—See Rubber.

ONION OIL—A yellowish liquid of penetrating odour and sp. gr. about 1·04, containing allyl compounds, including allyl-propyl disulphide. It is soluble in ether and chloroform, and used in flavouring.

Garlic oil contains allyl-propyl disulphide and allyl sulphide [$(C_3H_5)_2S$], has a sp. gr. of 1·05, and is soluble in alcohol and ether.

ONYX or CHALCEDONY—A native coloured form of agate or nearly pure silica (a chalcedonic variety of quartz), the best specimens coming from India. (See Silica.)

OOLITE—Varieties of limestone rocks.

OPAL—Uncleavable varieties of colloidal quartz, containing more or less water in combination. (See Silica.)

OPIUM—The dried juice extracted from the seed vessels of the poppy (*Papaver somniferum* and other varieties of the N.O. Papaveraceæ),

OPIUM (*Continued*)—

containing, amongst other substances, several alkaloids, including about from 10 to 18 per cent. of morphine ($C_{17}H_{19}NO_3.H_2O$)—a powerful drug used medicinally for the relief of pain and as a soporific—and from 2½ to 10 per cent. of narcotine ($C_{22}H_{23}NO_7$). Among other alkaloids associated with these are codeine ($C_{18}H_{21}NO_3H_2O$), thebaine ($C_{19}H_{21}NO_3$), papaverine ($C_{20}H_{21}NO_4$), and narceine ($C_{23}H_{27}NO_8,3H_2O$). It is collected chiefly in Asia Minor, Turkey, India, China, Persia (in which three last-named districts the *album* variety is chiefly cultivated), Straits Settlements, and Egypt. The British Indian production of raw opium in 1923 was 1,887,872 lbs. The morphine content of the bulk of East Indian opium is stated to lie between 7 and 12·5 per cent. It has been found that meconic acid ($C_7H_4O_7$) (a white, crystalline body, soluble in water and alcohol) is present in Indian opium in quantity roughly equivalent to the total alkaloids, and it is suggested that these are contained as meconates in the opium.

By extraction with warm water and addition of an equal volume of alcohol and excess of ammonia, morphine and narcotine are precipitated, and the narcotine can be extracted from the precipitate with benzene or chloroform, the morphine being insoluble. When the mother liquor is treated with acetic acid, salts of the strong bases codeine and thebaine are formed, and papaverine may then be extracted with benzene. The mother liquor yields thebaine by precipitation with ammonia or alkali, codeine remaining in solution. (See S. I. Kanewskaja, *B.C.A.*, 1924, B, 1028.)

The various alkaloidal bases are accompanied with about 8 per cent. saccharine matter and some 35 per cent. gum, resinous, fatty, and albuminous compounds.

Many of the morphine salts, including the acetate, hydrochloride, nitrate, and sulphate, are soluble in water, and are used in medicine. It is alleged that J. McLang has succeeded in effecting the synthesis of morphine.

The trade before the Great War was chiefly in the hands of Turkey, the Indian opium poppy of the same species having a smaller morphine content, but by selection and crossing of various varieties it is hoped to produce opium of the desired qualities, and already chemical investigations have disclosed races yielding as much as 18 per cent. morphine.

Morphine melts at 230° C.
Codeine ,, 154·9° C.
Thebaine ,, 193·0° C.

all of which are white, crystalline bodies, soluble in water, alcohol, and ether.

Papaverine melts at 147·0° C., is insoluble in water, but soluble in hot alcohol and benzene.

Narceine is soluble in alcohol, but hardly soluble in water.

Narcotine (m.p. 176° C.) is a white, crystalline body, insoluble in water, but soluble in chloroform and to some extent in alcohol and ether. It acts like morphine on the sensory cells, although less decidedly, and is not so poisonous.

OPIUM (*Continued*)—

Meconic acid ($C_7H_4O_7,3H_2O$ or $OH,C_5HO_2(COOH)_2.3H_2O$) is a white, crystalline body, soluble in water and alcohol.

"Chinese smoke" is a prepared form of opium known as "chandoo," and a variety of "faked opium" is made from prunes.

Paregoric elixir is a drug which should by the B.P. contain 5 per cent. by volume of tincture of opium.

(See J. N. Rakshit on "The Amounts of Morphine and Other Alkaloids contained in Various Opiums" (*Analyst*, 1926, **51**, 491); John Missenden (*C.T.J.*, 1923, **73**, 731, and 1924, **74**, 736); P. Laland on "Narcotine from Different Vegetables" (*Analyst*, 1932, **57**, 188); and Poppy-seed Oil.)

OPOPANAX—See Gums and Resins.

OPSONINS—See Bacteria.

OPTICAL ACTIVITY—See Light.

OPTOPHONE—See Selenium.

ORANGE OIL is obtained from the peel of the fresh fruit—the *sweet* oil from *Citrus aurantium* and the *bitter* oil from *C. bigaradia.* Both are used in perfumery and for flavouring purposes. The sweet oil contains 90 per cent. limonene, some hesperidene, together with other bodies; sp. gr. 0·847 to 0·851 at 15° C.; opt. rot., +97° to +100° at 20° C.; and ref. ind., 1·4710 to 1·478 at 20° C. The bitter (peel) oil has a sp. gr. 0·848 to 0·853; opt. rot., +96° to +99°; and ref. ind., 1·4730 to 1·4770. (See F. J. de Villiers, *B.C.A.*, 1930, B, 639.)

ORANGE-FLOWER OIL—See Neroli Oil.

ORANGEITE—A mineral, amorphous, hydrated silicate of thorium, of sp. gr. 1·9 to 2·3. (See Thorium.)

ORCHIL—See Archil.

ORCINOL ($C_6H_3.(CH_3).(OH)_2$) is stated to be contained in the free state in the various orders of lichens (referred to under the heading of archil), which are used for the production of litmus and archil, as also in the many acids and ethers which can be distilled from these lichens, although it is chiefly produced by the decomposition of orsellinic acid ($C_7H_5(CO_2H).(OH)_2$). It is prepared by crushing 5 parts of *Rocella fusiformis* with 55 parts of lime lactate and 2 parts of lime, filtering the mush, treatment of the filtrate with hydrochloric acid to precipitate erythrin, and heating the product with alkali, thus forming orcinol. It is a crystalline body which can be distilled at 288° C. without decomposition, and can be rendered anhydrous by exposure over sulphuric acid. It has a sweet taste, and in contact with ammonia and air it is converted into orcein ($C_7H_7NO_3$), assuming a deep purple colour.

The anhydrous crystals melt at 107·3° C. (See Archil and Lichens.)

ORDEAL BEAN—See Calabar Bean.

ORES AND THEIR TREATMENT—Ores are metals or compounds of metals as found in nature, derived from the outer crust of the earth, and concentrated by natural processes.

ORES AND THEIR TREATMENT (*Continued*)—

The geologist indicates how ores can be found, and it is the function of the chemist to utilize them. Veins or *lodes* differ in character from the rock environment, while *outcrops* are mineral deposits occurring at the surface, the "gangue" is valueless vein-matter. Ore deposits are sometimes found in gravel and other alluvial deposits, and in other cases disseminated through igneous and sedimentary rocks. As a rule, only materials of a certain grade of richness can be worked profitably, but others with small percentages, such as some tin ores, containing 1 per cent. of the metal, may be successfully handled: it all depends upon many circumstances, such as the value of the ultimate product and the cost of production.

From a number of considerations it has been suggested that the earth consists of a vast metallic ore composed mainly of an alloy of iron and nickel enclosed in a comparatively thin shell of earthy minerals. (See H. S. Washington on "Radical Distribution of Certain Elements in the Earth" (*Acad. Sci.*, 1924, **14**, 435-442, and *J.C.S., Abs.*, March, 1925, II., 234.)

The generally accepted modern view of the formation of mineral deposits is that (1) they have been solidified from molten matter as igneous rock; (2) have been deposited mechanically by breaking up of some pre-existing rock; (3) have been produced by chemical interaction; (4) or organically from a solution derived from some older rock; and that from such changes the four classes of minerals result —viz., the igneous, sedimentary, chemical, and organic.

The treatment of ores, with the view of separating their various metallic or other constituents, necessarily varies according to their nature, and many of the processes, including oxidation by roasting, etc., are described under the headings of the individual metallic elements. (See Gold, Lead, Silver, and Zinc.)

In the "cyanidation" treatment of gold and silver ores of Northern Canada, calcium cyanide is said to be supplanting potassium and sodium cyanides. Prepared as "Aero Brand," it contains some 50 per cent. $Ca(CN)_2$, 10 per cent. CaO, and a little Na(CN), being made by fixing pure nitrogen (from the distillation of liquid air at $-175°$) in powdered calcium carbide at a white heat; the metals being dissolved as double cyanides. (See C. Spearman, *J.S.C.I.*, 1925, **44,** 174 T and 179 T.)

For the treatment of mineral ores, fuel residues, etc., by magnetic separation, several types of machines are now available. (See article by B. I. Rolling, and report of discussion thereon (*C.T.J.*, 1925, **77,** 681 and 719).)

A method of separation now largely used, particularly in respect of lead and zinc sulphides, is that known as "flotation," in which various liquids such as amyl alcohol, creosote oils, cresylic acid, eucalyptus oil, pine spirit, and turpentine are variously employed, while in the case of copper ores petroleum products are favoured. The powdered ore is mixed with water in the proportion of about 1 ton to 4 or 5 tons, and there is then added from $\frac{1}{2}$ to 2 lbs. of the "flotation"

ORES AND THEIR TREATMENT (*Continued*)—

	1923. Tons.	1924. Tons.	1925. Tons.
Coal	276,000,560	267,118,167	243,176,231
Iron ore and ironstone (total) ...	10,875,211	11,050,589	10,142,878
ALL OTHER MINERALS :			
(1) *Non-ferrous Ores:*			
Tin ore, dressed (black tin)	1,760	3,547	4,032
Lead ore, dressed	12,499	14,249	15,578
Zinc ore, dressed	2,124	2,317	1,603
Tungsten ore, dressed ...	2	2	1
Uranium ore, dressed ...	4	20	114
Copper precipitate	138	192	148
Manganese ore	2,021	2,457	820
Chromite	546	1,043	448
(2) *For Chemical and Allied Industries:*			
Arsenic (white and soot) ...	1,605	3,207	2,545
Arsenical pyrites	729	299	—
Iron pyrites	6,908	5,569	5,288
Bog ore	17,839	3,200	4,791
Ochre, umber, etc.	10,293	10,469	11,224
Salt	1,868,672	2,027,450	1,866,581
Barytes and witherite :			
Not ground	31,758	40,926	36,366
Ground	11,739	13,841	12,345
Celestine (strontium sulphate)	6,346	1,450	1,072
Gypsum	317,676	371,289	414,302
China clay	720,533	806,364	850,160
Mica clay	18,270	23,633	20,834
Potter's clay	210,445	225,951	206,826
China stone	51,343	54,703	57,379
Felspar	3,246	1,053	—
Felsite	38,155	35,908	36,127
Calcspar	9,083	9,306	12,807
Alum shale	4,859	1,709	—
Soapstone	186	—	—
Oil shale	2,860,633	2,857,103	2,464,829
Petroleum	136	312	383
(3) *Minerals used in Iron and Steel and other Smelting Processes:*			
Fluorspar	49,031	49,492	39,079
Ganister (including silica rock, silica stone, and silica sand used as refractories)	591,348	634,431	494,293
Moulding and pig-bed sand	430,605	648,840	679,559
Fire-clay	2,120,310	2,189,348	2,240,529
(4) *Minerals for Building and Road-making, and for all other Purposes:*			
Limestone	11,431,552	12,813,471	13,060,753
Chalk	3,593,354	4,402,560	5,035,350
Sandstone	2,282,858	2,531,917	2,888,741
Slate	205,147	287,705	305,763
Clay and shale	8,500,730	10,843,418	13,073,940
Chert, flint, etc.	87,125	148,279	134,688
Gravel and sand	2,517,354	2,922,485	3,741,961
Igneous rocks	6,747,046	7,432,696	8,185,856

ORES AND THEIR TREATMENT (*Continued*)—

agent, so as to produce frothing when air is blown through the mixture, with the result that the sulphide ore concentrates in the froth, while the heavier quartz and other impurities sink to the bottom or remain in slight suspension in the water; sometimes an oxidizing agent is also added. Alkaline xanthates are sometimes used as "absorbing collecting agents," inducing the mineral particles to cling together at the interface between the aqueous solution and the frothing agent layer.

The important factors are agitation, solubility or miscibility of the flotation liquid (usually oil), the surface tension, and the size of the ore particles, these factors being interdependent, as the more the oil goes into solution, the more the bubbles are diminished.

It would appear that the flotation process depends upon the adequate formation of flocculent aggregates of solid particles and air bubbles, independently of opposing electrical charges. Again, it is stated that the selective agency by means of which the flotation method separates substances like galena from its associated quartz and calcite depends in the main on the contact angle formed by the oiled surfaces. In other words, the mineral sulphides, etc., are wetted by certain oily bodies and not by water, which, on the other hand, gives preference to quartz in the capacity of wetting.

The froth may be broken up by spraying with water, but usually the concentrates are passed direct into a pressure filter, thus collecting the solid separated ore for such further treatment as may be expedient.

The froth-flotation process has also been applied to the purification of coal by the elimination of shale and other waste material with which it may be associated.

It is to be noted that many substances of greater density than water will float when dusted on it in a pulverized condition, particularly those which are insoluble in it, while others can be made to float or be involved in froth by increasing the density of the medium or attachment of oily matter to the ground material to be treated.

Ores containing as little as 0·5 per cent. copper in the form of sulphide have been successfully treated, 90 per cent. of the copper being recovered as concentrate assaying some 20 per cent. of the metal.

Flotation practice at the Sullivan Mill is described by C. T. Oughtred (*B.C.A.*, 1929, B, 602), and in connection with the chlorine process of platinum metals from ores by Cooper and Watson (*Ibid.*). The use of chemicals, including flotation reagents, is the subject of papers by L. Sulman (*C.T.J.*, 1930, **86,** 350) and B. W. Holman (*Ibid.*, **87,** 507).

It is stated that some seventy million tons of ore, most of them being of low grade and not concentratable by any other methods, are annually treated by flotation processes. (See Serial 2931 by A. M. Gaudin, U.S. Bureau of Mines, Dept. of Commerce, Washington, D.C.)

In the froth flotation of coal, the addition of starch solution and certain other substances is stated to inhibit the flotation of fusain, which may thus be separated from the clarain and vitrain constituents of the coal. (See Coal, p. 213.)

Of all ores of the nature of sulphur-containing minerals, zinc con-

ORES AND THEIR TREATMENT (*Continued*)—

centrates rank the lowest in respect of combustion, involving as they do the employment of extraneous heat, to ensure satisfactory desulphurization. A description of the various burners used in respect of sulphur-containing materials is given by P. Parrish (*C.T.J.*, 1925, **76,** 481, 485, and 509).

It will be seen from references to the methods of extracting various metals from their ores that coal and coke are in many cases used for the reduction of oxides, without proper attention being paid to intimate details of such processes, and the author of this work suggests that in some cases these materials could be replaced with great advantage by the use of soot, wood flour, shales, pitch, and asphaltic materials, regard being had, of course, to local conditions where such materials are readily available, and particularly to soot, of which many millions of tons are produced annually, and is so generally available. The whole mass to be treated should first of all be thoroughly well mixed by some grinding and (or) mixing machinery, with or without some agglutinizing or supplementary agent to bind the materials together before the necessary heat is applied in the rotary or other plant employed. In some cases, producer gas, or water gas of suitable composition, could be used in association if found desirable, although it would probably not be required.

Such processes or modifications of them could be used in respect of zinc ores, and possibly with advantage, in the manufacture of aluminium bronze, the recovery of antimony, and in place of the "serpek" process of making aluminium. (See description of Coley's Process under heading of Zinc.)

The output of minerals in the United Kingdom is shown in the table on page 644, extracted from the Annual Reports of the Secretary for Mines for the years ended December 31, 1923, 1924, and 1925 (H.M. Stationery Office, 1926). The reports for 1926 to 1930 are now available. (See *Chem. and Ind.,* 1929, **48,** 765, and **49,** 889.)

The British Empire and the world's production of the various metals during 1921 were given by the Imperial Mineral Resources Bureau as follows:

	1921. British Empire Production. (Thousand Tons.)	1921. World Production. (Thousand Tons.)
Iron ore	5,752	73,000
Pig iron	3,957	36,500
Steel ingots and castings	4,719	38,700
Copper ore (in terms of metal)	46	537
Smelter copper	53	580
Lead ore (in terms of metal)	199	869
Smelter lead	136	849

(See *Flotation,* by Mayer and Schranz (S. Hirzel, Leipzig, 1931); Calcination, Clay, Elutriation, Furnaces, Levigation, Metallography, Metallurgy, and Minerals.)

ORGANIC ANALYSIS—The percentic amounts of carbon and hydrogen contained in organic substances are determined for the most part by

ORGANIC ANALYSES (*Continued*)—

a process of combustion, and, taking sugar by way of example, the method may be described as follows: a definite weight is taken and, after admixture with oxide of copper (so as to moderate the action of the oxygen gas, as referred to later), placed in a little platinum vessel (boat) small enough to be pushed into a length of glass combustion tubing. The tube containing the boat is then placed in a combustion furnace, suitably equipped and connected with, first of all, a drying-tube of previously ascertained weight, and then with so-called potash (Liebig's) bulbs charged with a solution of potassium hydroxide of sp. gr. 1·26, also of previously ascertained weight.

This "combustion furnace" is extensively employed for exposing solid substances up to a red heat (but below that of the melting-point of the combustion-tube) to a current of air, oxygen, or other gas, in order to study the effects produced, by subsequent examination of the gaseous and residual products, and still more often for the quantitative determination of their constituents. It consists of a great number of Bunsen burners set in a row, and all rising up from a larger gas-supply pipe below, with which they are connected. They sometimes terminate in and are surrounded by hollow perforated cones or blocks of earthenware, which break up the flame and bring the entire mass to a glowing red heat when in use. The iron framework is so constructed that the heat can be more or less concentrated on the combustion-tube by means of earthenware tiles arranged at the sides, and others which can be placed over the top of the channel (running along and over the tops of the burners below) in which it rests.

Reverting now to the analysis of sugar, a gentle current of dried oxygen gas is passed through the combustion-tube, while it is gradually heated to redness in the furnace. This causes the decomposition of the sugar, which consists of carbon, hydrogen, and oxygen ($C_{12}H_{22}O_{11}$), with the result that the carbon is burned off as carbon dioxide (CO_2) and the hydrogen as water (H_2O). The water is absorbed by the sulphuric acid or calcium chloride contained in the drying-tube, and the carbon dioxide is absorbed by the potash in the bulbs; and from the weights of these appliances after the combustion is completed, it is known that the increases are due to the absorbed products; and knowing how much carbon and hydrogen are severally contained in given quantities of carbon dioxide and water, it is easy to calculate the amounts therefrom. These will be found to make up so much of the weight of the sugar, and the other part necessarily consists of oxygen, which is the only other constituent of the sugar, and which it is therefore unnecessary to specifically determine otherwise.

To determine the nitrogen content of organic substances, the combustion is, in the main, conducted as already described, but a current of carbon dioxide is first of all used to clear out the air from the combustion apparatus, and, after the combustion, to sweep out any remaining nitrogen gas, which gas is collected by displacement in an inverted tube of mercury standing in a dish of potassium hydroxide (of strength 1 : 2) and measured (making due corrections for temperature and pres-

ORGANIC ANALYSES (*Continued*)—

sure), and from this measurement its weight is calculated. Any oxygen that may be admixed with the nitrogen gas is first of all absorbed by introducing an alkaline solution of pyrogallic acid. Among other forms of nitrometers for collecting and measuring the nitrogen, the "Schiff" and the "Schwarz" may be used.

For a rapid method of determining organic nitrogen in wheat flour, fertilizers, and soils see Q. Jaramillo (*B.C.A.*, 1926, A, 1163). The "Kjeldahl" and the improved "Kjeldahl-Gunning" methods of determining nitrogen in industrial products are described by Vincent Edwards (*Ind. Chem.*, 1925, i., 122). (See also Kjeldahl's Process.)

The "ter Meulen" process for determination of the oxygen content of organic substances consists of combustion in quartz tubes in a current of hydrogen, whereby the oxygen is converted into water and weighed as such, catalysts being used to promote the hydrogenation. (See Eudiometer and Nitrogen, p. 611.)

In other cases, instead of using cupric oxide in making organic analyses, fused lead chromate reduced to powder is employed as oxidizing agent, and there are well-understood methods of determining the percentages of any other constituents, such as sulphur or phosphorus. The method of ascertaining the molecular weights of organic compounds is referred to under the heading of Molecules and Molecular Weights. *Other references:* A "handbook" by H. T. Clarke (E. Arnold and Co.); *Organic Analysis*, by Barnett and Thorne (University of London Press); *A Student's Manual of Organic Chemical Analysis*, by J. F. Thorpe and M. A. Whiteley (Longmans, Green and Co.); and Allen's *Commercial Organic Analysis*, fifth edition (J. and A. Churchill); Drying-Tubes and Micro-Chemistry.

ORGANIC BASES—See Bases.

ORGANIC CHEMISTRY—Books on this subject include one by F. S. Kipping and F. B. Kipping (W. and R. Chambers, Ltd.); one by L. Remsen (Macmillan and Co., Ltd); others by J. B. Cohen, fifth edition (E. Arnold and Co.); by A. F. Holleman, seventh edition (Chapman and Hall); Julius Schmidt's textbook, translation by H. G. Rule (Gurney and Jackson); *Organic Synthesis*, by F. C. Whitmore (Chapman and Hall); Bernthsen's *Organic Chemistry*, by Sudborough (Blackie and Son, Ltd.); and *Practical Organic Chemistry*, by Sudborough and James (Blackie and Son, Ltd., London).

ORGANIC COMPOUNDS—Their preparation by electrolytic methods is the subject of papers by S. Glasstone (*Ind. Chem.*, 1929, v., 423; 1930, vi., 201; and 1931, vii., 139, 209, and 315). (See also Carbon.)

ORGANIZED—Arranged in definite form or structure, such as cells, fibres, membranes, hair, skin, etc.

ORGANO-METALLIC COMPOUNDS—Comprise a numerous class of colourless, mobile, liquid substances of volatile character in which organic radicals, such as the alkyl groups, are combined with metals; for example, zinc di-methyl ($Zn(CH_3)_2$), zinc di-ethyl ($Zn(C_2H_5)_2$),

ORGANO-METALLIC COMPOUNDS (*Continued*)—

aluminium tri-methyl ($Al(CH_3)_3$), and lead tetra-methyl ($Pb(CH_3)_4$). They correspond to the chlorides from which they are derived, are decomposed by water, and burn explosively in the air. Zinc di-methyl and zinc di-ethyl are heavy, colourless liquids, boiling at 46° and 118° C. respectively, and spontaneously fire when exposed to the air.

By oxidation, zinc di-ethyl yields zinc ethylate ($Zn(C_2H_5O)_2$), and this by further oxidation gives zinc acetate ($Zn(C_2H_3O_2)_2$).

Mercury, tin, and some other metals yield phenyl derivatives—mercury phenyl ($Hg(C_6H_5)_2$), for example (obtained by the action of sodium amalgam on bromobenzene). Some other organo-metallic compounds are described under the respective metals concerned. (See F. Challenger on "Organo-Derivatives of Metals," etc. (*Ind. Chem.*, 1927, iii., 125) and vol. xi. of J. N. Friend's *Inorganic Chemistry* (Griffin and Co., London).)

ORGANOPLASTICS—Components of vegetable and animal tissues and organs such as albumin, chitin, fibrin, keratin, gelatin, mucin.

ORGANOSOLS—Colloid disperse systems having organic liquids as the dispersion medium. (See Colloid Chemistry.)

ORIENTATION—The relative positions of substituted constituents in relation to the parent substance and each other.

ORIGANUM OIL—See Thyme Oil and Thymol.

ORMOLU (Mosaic Gold)—See Alloys and Mosaic Gold.

"ORPIMENT"—Trade name for mineral arsenic triculphide (As_2S_3) of crystal system, No. 4, and sp. gr. 3·5. (See Arsenic Compounds.)

"ORR'S ZINC WHITE"—See Lithopone (under Paints).

ORRIS OIL—A yellowish, semi-solid, fatty substance distilled from the rhizome of *Iris florentina, I. pallida,* and *I. germanica,* natives of the South of Europe. It melts at 44° to 50° C., is soluble in alcohol and ether, and used in making perfumes and cosmetics. It contains myristic acid (85 per cent.) and proportions of caprylic, pelargonic, capric, undecylic, lauric, tridecylic, and benzoic acids, together with irone (5 to 10 per cent.); has a sp. gr. of 0·93 at 15° C., and opt. rot. +12° to +30° at 20° C. (See Langlais and Goby, *Analyst*, 1924, **49**, 542; also Ionone and Irone.)

ORTHITE (Allanite)—Crystal system, No. 5, and sp. gr. 3·0 to 4·0. A published analysis of a specimen from Ambatofotiskely is as follows: SiO_2, 30·42; ThO_2, 2·37; AL_2O_3, 17·00; Ce_2O_3, 8·09; La_2O_3, 8·13; Y_2O_3, 1·42; Fe_2O_3, 5·45; FeO, 11·96; MnO, 0·80; CaO, 13·38; H_2O, 0·73 per cent. (See analyses of other specimens (Llord Y. Gamboa, *B.C.A.*, 1927, A, 851, and *B.C.A.*, 1929, A, 1264); also Europium and Lanthanum.)

ORTHOCLASE—A kind of felspar or potassium-aluminium silicate of crystal system, No. 5, and sp. gr. 2·4 to 2·6.

ORTHO COMPOUNDS are substitution products derived from benzene, in which the substituting radicals or groups are constitutionally situate in certain definite (adjacent) positions in the nucleus (1 to 2, for example, as in ortho-cresol and dichlorbenzene).

ORTHO-CRESOL—See Cresol.

ORTHO-NITRANILINE—See Nitranilines.

ORTHO-TOLUIDINE—See Toluidine.

ORUJO—See Olive Oil.

OSAGE ORANGE—A material obtained from the bark of the osage orange tree (*Maclura aurantiaca,* N.O. Moraceæ), of the same genus as fustic, indigenous in North America, containing some 25 per cent. tannin, and used as a dye.

OSAZONES—Compounds of sugar and phenylhydrazine used to separate and identify individual sugars.

OSMIRIDIUM (**Iridosmine**)—A natural deposit containing osmium and iridium, with varying proportions of rhodium, ruthenium, and platinum, found together with platinum deposits and certain gold washings. It occurs for the most part in irregular grains of sp. gr. about 20·0, and is recovered to some extent from "banket ore" of the Rand mines, and from mineral deposits near Waratah, Tasmania. When heated in the air, it is stated to give off osmium tetroxide.

The "black sands" collected from the amalgamation plates, etc., are stated to contain iridium to the extent of 3 ozs. per ton. (See Iridium.)

OSMIUM (Os) **and its Compounds**—Atomic weight, 191; sp. gr., 22·48; m.p., 2,700° C. A rare element of the platinum group, and the most refractory; found in alloyed association with iridium in certain platinum ores, and notably in so-called *osmiridium,* in parts of which the osmium content runs as high as from 30 to 40 per cent. It is a hard, bluish-white metal, possessing catalytic properties and the highest sp. gr. of any known material. It can be prepared from its oxides by reduction; is known in crystalline and black amorphous forms, and burns brightly when strongly heated, forming osmium tetroxide, which can be condensed in crystalline white needles. The amorphous variety is dissolved by aqua regia, and the tetroxide is thus produced, but the compact form is insoluble in all acids. Four oxides are known, viz., OsO, Os_2O_3, OsO_2, and OsO_4, and there are salts corresponding to the sesquioxide. The tetroxide (osmic acid) is used in medicine and, to some extent, in making incandescent gas mantles, etc. Three chlorides are known—$OsCl_2$, $OsCl_3$, and $OsCl_4$.

"OSMO-KAOLIN"—A proprietary colloidal aluminium silicate prepared by a patented electro-osmose method.

"OSMO-SIL"—An amorphous form of silica of great purity, prepared by the electro-osmose process, and used as a powerful absorbent for dye-stuffs, etc.

OSMOSIS—The mixing of two liquids separated by a porous diaphragm; for instance, if a bladder containing alcohol be placed in a basin of

OSMOSIS (*Continued*)—

water, some of the spirit will pass through the diaphragm into the water, and some of the water will pass through into the alcohol. In most cases, the quantities of the two different liquids travelling in opposite directions are unequal. (See Diaphragms.)

If a porous earthenware vessel be substituted for the animal membrane and the pores thereof covered by the deposition thereon of a finely divided precipitate such as copper ferrocyanide (thus producing a semipermeable surface), it is found that, using a solution of sugar, endosmosis will occur—that is, water will pass therefrom through the surface, but the sugar dissolved therein will not permeate. If, therefore, a cell of unglazed porcelain be prepared coated internally in this way, charged with a solution of sugar and then immersed in water, the liquid will rise within the cell or tube to a certain extent above the level of the surrounding water by reason of the passage of the water through the cell, no sugar passing out; but when a certain pressure is reached, equilibrium is established (exosmosis), and water then passes in each direction at equal rates; so that by connecting such an appliance with a manometer the pressure reached can be measured and recorded as the "osmotic pressure." (See R. V. Townend for descriptions of particular apparatus (*B.C.A.*, 1929, A, 134) and Grigaut and Boutroux (*B.C.A.*, 1929, A, 761).)

Expressed otherwise, osmosis represents the increase in the volume of the dialyzing fluid in the interior of the cell, and this phenomenon is observed whenever a so-called dispersoid is brought in contact with a less concentrated one. In other words, the pressure is caused by the attraction of the solution for more of the solvent. At the same temperature and strength of solution, different substances exhibit different pressures, and it has thus been found that the analogy between the laws governing these phenomena and those relating to gaseous pressure is close, and that osmotic pressure increases with rise and diminishes with fall of temperature.

The term "dispersoids," as here used, means heterogeneous combinations of Graham's "sols" and "gels." "Isotonic solutions" are solutions of equal osmotic pressure, and true solutions give osmotic pressure in proportion to their molecular weights. (See Colloid Chemistry and Dialysis.)

Electro-osmosis—that is, osmosis supplemented by means of the electric current—finds application in many industries, and depends upon the fact that, under this influence, liquid conductors tend to filter through porous or semipermeable partitions with a speed independent of their thickness and only varying with their nature and section. Colloidal substances, which swell in water, often exhibit great absorbing capacities, and are capable of superficially fixing the molecules or ions of bodies dissolved in the liquids in which they may be immersed in a chemical manner, and it is this property which is utilized, for example, in the electro-osmotic process of tanning with chromium salts. This phenomenon is due to the fact that at the contact boundary between a solid and a liquid, each assumes an electrical charge of

OSMOSIS (*Continued*)—

opposite character; in some cases the solid gains the positive charge, while the liquid becomes electro-negative; the electrification of the granules and liquid being due to the utilization of the ions formed by the salts always present in water.

Cataphoresis means the migration of a sol or the disperse towards anode or cathode (the electrodes) under influence of electric charge due to the production of potential differences at the interface between liquid and solid; positive sols such as the metallic hydroxides pass to the cathode, and negative ones such as metals to the anode.

References to the application of electro-osmotic processes will be found under various headings, including Silica, Clay, Peat, Rubber, and Tanning. (See also W. E. Adeney (*J. Inst. Chem.*, 1932, Part I., p. 41).)

OSSEIN—A variety of gelatin or albuminous substance present in and prepared from bones. (See Bones and Gelatin.)

OSTEOLITE—A form of apatite. (See Apatite and Calcium (Phosphate).)

OSTWALD'S DILUTION LAW—See Solution.

OSTWALD'S RULE—When a substance which can exist in more than one modification is formed, the least stable one is first formed; this may then change sooner or later into the stable one.

OTOBA BUTTER—The fat expressed from the fruit of *Myristica otoba*, containing glycerides and some sesquiterpenes; sap. v., 185; and m.p., 34° C. (See Mace and Nutmeg.)

OTTO OF ROSES—See Attar of Roses.

OX GALL—The bile obtained from the gall bladder of oxen—a ropy, mucous, transparent liquid of greenish-brown colour used for wool-scouring and in the engraving and litho trades. (See Bile.)

OXALATES—Compounds of oxalic acid with metals and bases. The alkaline oxalates are soluble in water, but the others are for the most part insoluble.

OXALIC ACID ($C_2H_2O_4,2H_2O$ or $CO_2H.CO_2H.2H_2O$) may be regarded as an oxidation product of the alcohol named ethylene glycol ($C_2H_6O_2$), and is dibasic. It occurs combined with potassium as oxalate ($K_2C_2O_4$) in many plants, particularly in wood-sorrel (*Oxalis acetosella*) and varieties of *Rumex;* in the free state in some varieties of *Boletus*, and as calcium oxalate in rhubarb root and many lichens and fungi. It is also found in the form of calcium oxalate among the products of changes induced by the growth of *Aspergillus niger* in sugar solutions containing salts including calcium carbonate. (See F. Challenger and others, *J.C.S.*, 1927, p. 200.) Urinary deposits and calculi also often contain the calcium salt. It can be made by the action of nitric acid upon sugar, or by fusing a mixture of cellulose (sawdust) with potassium or sodium hydroxide at from 200° to 230° or 240° C. in flat iron vessels: the fused mass is afterwards extracted with water, and upon

OXALIC ACID (*Continued*)—

addition of calcium chloride, insoluble calcium oxalate (CaC_2O_4) is precipitated, and from this compound oxalic acid is obtained by treatment with sulphuric acid. The soft woods give a better yield of oxalic acid than the hard woods.

It can similarly be obtained from sugar and starch.

There is a German patented method for preparing it by the passage of acetylene gas through nitric acid of sp. gr. 1·305 containing a little mercuric nitrate, at a temperature of 15° C. Oxalic acid crystallizes out, and the nitrogen oxides which are evolved are reconverted into nitric acid for use over again. The solution from which the oxalic acid crystallizes out is stated to contain a little glyoxal.

The "formate" process of making oxalic acid, which has practically superseded the older sawdust method, consists of heating sodium carbonate with carbon dioxide under pressure, thus producing sodium formate ($NaCHO_2$), and when this is heated with sodium carbonate, sodium oxalate is produced:

$$2H.COONa = (CO_2)_2Na_2 + H_2,$$

the reaction being slightly endothermic. By adding a calcium salt to the solution of sodium oxalate, calcium oxalate is precipitated, and when that compound is treated with sulphuric acid, the oxalic acid is set free. As an alternative the sodium oxalate is treated with lime and producer gas at 200° C. and under a pressure of 15 atm., yielding sodium formate and calcium oxalate.

A modification consists in introducing carbon monoxide into caustic soda, thus producing sodium formate, which, upon heating in a furnace under pressure, yields sodium oxalate by loss of hydrogen and treatment of this product with sulphuric acid. (See Sodium (Oxalates).)

A ready method of preparing the anhydrous form from the hydrated acid by distillation with toluene is described by J. R. Partington (*J.C.S.*, 1930, p. 1510).

Oxalic acid is very poisonous, crystallizes in large transparent rhombic prisms, which slowly effloresce in the air, is soluble in water and to some extent in alcohol. The hydrated acid melts at 98° C. in its water of crystallization; at 100° C. it loses this water and becomes anhydrous, while at 110° to 120° C. it decomposes and yields a mixture of carbon monoxide and dioxide together with water.

Oxalic acid is used in the dyestuffs and textile industries; in bleaching straw, wood, cotton-linters, etc.; in preparing inks, and for various other applications, including brass cleaning. Ammonium oxalate $[(NH_4)_2C_2O_4,H_2O]$ is used as an analytical reagent, while the potassium binoxalate (KHC_2O_4,H_2O) (salt of sorrel) is used for cleaning brass and removing ink stains. The ferrous-potassic oxalate ($FeK_2(C_2O_4)_2$) is a powerful reducing agent, and is used in photography as "oxalate developer."

OXAMIDE—See Amides.

OXIDASES—See Enzymes.

OXIDATION is a process by means of which oxygen is either added to a substance (as in the simple case of converting mercury into its red oxide by heating it in air or oxygen) or made to remove hydrogen from a substance, as in the oxidation of ethyl alcohol into aldehyde:

$$C_2H_6O + O = C_2H_4O + H_2O.$$

When the process is carried still further, oxygen is also added, acetic acid being produced:

$$C_2H_6O + O_2 = C_2H_4O_2 + H_2O.$$

Combustion of organic matters and the roasting of metallic sulphides are also acts of oxidation. The subjects of electro-chemical and bio-chemical oxidation processes are dealt with by Fr. Fichter (*J.S.C.I.*, 1929, **48,** 325 T, 332 T), 341 T, 347 T, and 354 T). (See also the Messel Memorial contribution on auto-oxidation, etc., by C. Moureu and C. Dufraisse (*Chem. and Ind.*, 1928, **47,** 819) and Oxidizing Agents.)

OXIDES—See Bases and Oxygen.

OXIDIZING AGENTS—Chemical substances which are capable of introducing or giving up oxygen to other substances having an affinity for it, including air, hypochlorous acid, oxygen, ozone, and many substances rich in oxygen, as, for example, potassium permanganate ($KMnO_4$), potassium dichromate ($K_2Cr_2O_7$), chromic anhydride (CrO_3), nitric acid (HNO_3), and the various peroxides. For instance, gaseous ammonia is oxidized by chromic anhydride, which substance is reduced thereby to sesquioxide, as shown by the equation:

$$2NH_3 + 2CrO_3 = Cr_2O_3 + N_2 + 3H_2O.$$

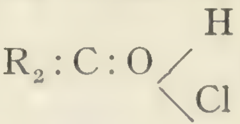
(See Anti-oxidants and Oxidation.)

OXIMES—A series of bodies obtained from aldehydes and ketones by condensation of the carbonyl group (C : O) with hydroxylamine ($NH_2.OH$). Acetone, for example, yields acetoxime:

$$(CH_3)_2C : O + NH_2OH = (CH_3)_2C : N.OH + H_2O.$$

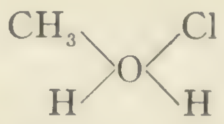
"OXOID"—A proprietary thyroid gland preparation stated to contain ½ per cent. iodine.

OXONIUM COMPOUNDS (Salts) resembling ammonium salts of the type



$$R_2 : C : O \begin{smallmatrix} H \\ Cl \end{smallmatrix}$$

in which oxygen exhibits a tetravalent function —for instance,



formed by combination of methyl alcohol with hydrochloric acid.

OXY-ACETYLENE FLAME—The complete reaction is thus represented:

$$2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O,$$

so that one volume of acetylene requires 2½ volumes of pure oxygen for complete combustion. The temperature is from 3,100° to 3,300° C.

One type of lead-burning outfit is known as the "Alda."

OXY-ACIDS (Oxacids)—Acids which contain oxygen as a constituent, such as cyanic acid (HCNO) and chloric acid ($HClO_3$).

OXYCHLORIDES—Compounds containing both oxygen and chlorine in combination with some other element—for example, magnesium oxychloride $MgCl_2 5MgO$ and the antimony compounds $SbOCl_3$ and SbO_2Cl.

OXYDASES—See Enzymes.

OXY-SALTS—Salts of oxy-acids, such as carbonates, sulphates, etc.

OXYGEN (O) **(and its Compounds) and OZONE**—Oxygen (atomic weight, 16; m.p., −218° C.) was originally obtained by heating the red oxide of mercury in the concentrated rays of the sun through the medium of a powerful lens. It is now said to have two isotopes with masses of 17 and 18, a circumstance which necessarily raises the question as to which variety is to be taken as the standard of atomic weights.

In combination with hydrogen, it exists in water (making up eight-ninths of its weight), and it has been roughly estimated to form nearly one-half by weight of the various rocks of which the earth's crust is composed.

Oxygen gas is not only yielded by electrolysis of water and by heating the red oxide of mercury:

$$HgO = Hg + O,$$

but a number of so-called peroxides, of which manganese dioxide is typical, yield to the same heat treatment:

$$3MnO_2 = Mn_3O_4 + O_2.$$

That is to say, the manganese dioxide gives off oxygen gas, and is reduced to a lower state of oxidation when heated to redness.

Barium peroxide (BaO_2) behaves similarly:

$$BaO_2 = BaO + O,$$

the change taking place at a temperature of 1,400° C., and when completed, the BaO can be reconverted to BaO_2 by exposing it to a current of air under pressure at the lower temperature of 700° C. It is upon the basis of these two alternate changes that Brin's method of manufacturing oxygen is based. This process has been very largely superseded by methods dependent upon fractionation of liquefied air, as referred to below, so far as the production of pure oxygen is concerned, but it is serviceable for yielding supplies of oxygen-enriched air, the use of which is called for in large quantities in metallurgical operations.

Potassium chlorate ($KClO_3$) when heated to a state of fusion also gives off oxygen, being reduced to the chloride (KCl).

The oxygen of the air (of which it constitutes about one-fifth) can be separated from the associated nitrogen by chemical means, and its liquefaction is effected by pumping it at a very low temperature and under great pressure into vessels made exceedingly cold. From liquefied air the two gases, nitrogen and oxygen, pass again into the state of vapour at different temperatures. Nitrogen boils at −195·7° C. under atmospheric pressure, and oxygen at −182·9° C.; so that it is possible to boil off the nitrogen—or most of it—before the oxygen, and this process is now used for the manufacture of both liquid oxygen and nitrogen on a large scale.

OXYGEN (*Continued*)—

The various types of electrolytic cells used for the commercial production of oxygen (and hydrogen) from water are referred to under Hydrogen, and are described by J. B. C. Kershaw (*Ind. Chem.*, 1925, i., 98, 149, 206). (See also A. E. Knowles on "The Manufacture of Oxygen" (*C.T.J.*, 1925, **77**, 589).)

Oxygen is still liquid at –210°, and in this form is of a pale steel-blue shade of colour and exhibits strong magnetic properties. Each cubic foot of the liquid yields 800 cubic feet of gas. Among its many applications is that of its use as an explosive when mixed with combustible matter, such as sawdust or carbon. Liquefied oxygen itself is not explosive, but cartridges of paper filled with sawdust or other combustible soaked in the liquid oxygen for some five or ten minutes, when lighted in a closed space, such as a borehole made for blasting purposes, are highly explosive. A litre of oxygen used in this way is said to be the equivalent of 1 kg. of black gunpowder and very much cheaper. (See Explosives.)

Pure oxygen gas is largely used for the treatment of certain complaints by inhalation, also for many manufacturing and trade purposes, including lead-burning, and its employment alone or in association with hydrogen or acetylene for the production of flame used for the cutting and welding of metals. The amount of oxygen distributed in cylinders per annum is upwards of 300 million cubic feet. (See Acetylene.)

A patented process for preparing oxygen or air strongly enriched with oxygen consists in circulating through an absorption tower a 12 per cent. aqueous solution of hæmoglobin (the red colouring matter of blood) in contact with a stream of air at 0° C., and recovering the absorbed oxygen by a reduction of pressure. Alternatively, the solution may be kept just below the coagulating temperature of hæmoglobin (57° C.) in an absorption tower into which air is forced under a pressure of 1·5 atmospheres. It is stated that a 75 per cent. gas can thus be prepared, and may prove useful for some industrial applications, although not suitable for cutting and welding operations.

Another suggested method of enriching air with oxygen, known as the "Pressure Fractionation Process," has been described by T. Campbell Finlayson, and appears capable of yielding a supply of 30 to 40 per cent. oxygen gas at a reasonable price.

Pure oxygen gas is colourless, tasteless, and slightly soluble in water (1 volume at 0° C. dissolving 0·0489 volume of the gas), fish being dependent upon this dissolved quantity for respiration. In fact, oxygen is the only gas that is capable of supporting respiration, and the importance of oxygen in respect of respiration and combustion is referred to elsewhere. (See Air and Respiration.)

Oxygen exhibits powerful and widely spread affinities for other substances, forming various oxides with a great number of elements, combining with hydrogen to form water and hydrogen dioxide, and entering into the composition of an enormous number of chemical compounds. Its chemical activity is pronouncedly decreased by pro-

OXYGEN (*Continued*)—

longed drying, so that it will not combine with dry carbon, sulphur, phosphorus, hydrogen, etc., at temperatures at which otherwise it would do so; this change is accompanied by that of its dialectric strength (see H. L. Riley, *J.C.S.*, 1929, p. 1026). Some of the gas reactions of atomic oxygen have been described by Harteck and Kopsch (*B.C.A.*, 1930, A, 1388); see also Mecke and Childs respecting the alleged three isotopes of oxygen (*B.C.A.*, 1931, A, 543).

Ozone—When oxygen gas is subjected to the influence of the silent electric discharge, it is converted into what is called an allotropic state and becomes ozone. The chemical difference is that whereas the molecule of oxygen contains 2 atoms (O_2), that of ozone contains 3 atoms (O_3), and the properties of the two substances are perfectly distinct. An appreciable quantity of ozone is stated to result from introducing a few drops of water into gaseous fluorine as represented by the equation: $3F_2 + 3H_2O = 6HF + O_3$. Ozone is also produced when phosphorus is partially immersed in water and exposed to the air; ozone is formed in the air and hydrogen dioxide (H_2O_2) is formed in the water (Kingzett, *J.C.S.*, December, 1880). It has been alleged that the ozone is produced at that stage during which phosphorus oxide is undergoing oxidation (to which the luminescene is also due), and to be actually formed by the ultra-violet light thus emitted; the complete oxidation of phosphorus occurring in two stages, phosphorus oxide being the intermediate product.

When an electric machine is giving out high-voltage discharges, as in the use of induction coils, ozone is produced in the air, and this was the method employed by Brodie in his researches concerning ozone and its properties. (See L. A. M. Henry (*B.C.A.*, 1931, A, 1018); Briner and Susz (*B.C.A.*, 1930, A, 1135); and Induction Coils.)

A good yield of ozone is obtainable by the electrolysis of sulphuric acid of density 1·1 to 1·4 by superposed continuous and alternating electric currents, using an internally cooled anode of lead coated with lead peroxide or platinum (see *J.C.S. Abs.*, 1925, ii., p. 62). A laboratory ozonizer stated to be capable of producing concentrations of ozone in ozonized oxygen of 15 per cent. is described by L. I. Smith (*J.Amer.C.S.*, 1925, **47**, 1844-1850), and another by A. L. Henne (see *Analyst*, 1929, **54**, 685).

There are a number of appliances for generating ozonized air, all constructed on the principle of Siemens' original design, in which surfaces of tinfoil, separated by glass (which is dielectric), are connected with the secondary terminals of an induction coil. In the "Ozonair" thin mica plates alternating with metallic gauze electrodes are used, and it yields air charged with ozone to the extent of 500 to 1,500 parts per million.

As prepared by the use of these electrical "ozonators" it is used commercially for the sterilization of drinking water, the purification of air, the decolourization of sugar, juices, syrups, etc., the bleaching of wax, textiles and other fabrics, paper pulp, sponges, and for giving drying

OXYGEN (*Continued*)—

properties to oils, varnishes, and paints, and the seasoning of wood. A current of air containing a small percentage of ozone is alleged to be capable of seasoning timber in about twenty days to a state which is reached naturally only in the course of several years.

Ozone has been liquefied (Riesenfeld and Schwab), has a m.p. of $-251·4°$ C., a b.p. of $-112·3°$ C., and density of 1·71 at $-183°$ C., and in this condition it exhibits an intense blue colour and is extremely explosive. It instantly oxidizes nitrogen tetroxide to the pentoxide, as sharply indicated by the disappearance of colour.

Whereas oxygen is quite tasteless and odourless, ozone has a peculiar fishy odour, is soluble in turpentine, and exhibits very superior powers as an oxidizing and bleaching agent. For example, silver does not suffer oxidation when exposed to pure oxygen, but it is rapidly attacked by ozone and becomes peroxidized: it has also the power of decomposing potassium iodide, setting iodine free. By way of absolute proof that ozone and oxygen are identical in matter, it has been shown that they are mutually convertible; ozone being retransformed into oxygen by raising it to a temperature of 246° C., 2 volumes of ozone thus yielding 3 volumes of oxygen.

Ozone is not ordinarily found on the surface of the earth, but there is evidence of its presence in the upper atmosphere at high altitudes, and, doubtless, it is formed in lightning discharges when the oxygen of the air is subjected to electrical influences. It has been alleged that the high temperature of the air at great heights is due to the presence of ozone, which absorbs some 6 per cent. of the incoming solar energy. Its occurrence in the earth's atmosphere is discussed in a paper by Dobson and Harrison (*B.C.A.*, A, 403).

It is stated to be produced in small amount from oxygen after collision with electrons (Wansbrough-Jones, *Proc. Roy. Soc.*, 1930, A, **127,** 511 and 530), also by optically excited mercury vapour through reaction of excited or dissociated oxygen with normal oxygen (Dickinson and Sherrill, *B.C.A.*, 1926, A, 485), and it has been suggested that atomic oxygen is produced in the atmosphere by the absorption of certain ultra light bands as an antecedent to the formation of ozone (S. Chapman, *Phil. Mag.*, 1930, iii., No. 26, 103). (See article on "Industrial Ozone" (*C.T.J.*, 1926, **78,** 123), and Belton, Griffith, and McKeown on "The Thermal Decomposition of Ozone," etc. (*J.C.S.*, 1926, p. 3153).)

OXYHÆMOGLOBIN—The compound formed in the blood by the action of inspired oxygen on its hæmoglobin constituent, which carries oxygen to the animal tissues. (See Blood and Hæmatine.)

OXYHYDROGEN FLAME—Produced by burning a mixture of oxygen and hydrogen gases, when both ozone and hydrogen dioxide are said to be formed to some extent; until superseded by the electric furnace it was used, amongst other purposes, for the manufacture of artificial rubies and sapphires. Its temperature is about 2,800° C., and its mechanism is discussed by Reisenfeld and Wass (*B.C.A.*, 1930, A, 1126).

OZOKERITE—Mineral wax of yellowish-black or green colour occurring in the vicinity of coal in Galicia, Poland, Moldavia, Utah, Wyoming, etc.; soluble in benzol, turpentine, carbon disulphide, etc.; consists of paraffin hydrocarbons, and used in the manufacture of candles, sealing-wax, paints, polishes, etc.; sp. gr. 0·85 to 0·95, and m.p. varying between 65° and 80° C. By purification and bleaching it gives the ceresine wax of commerce. (See "Arma" on "Crude and Purified Ozokerites" (*C.T.J.*, 1932, **90**, 75) and Waxes.)

OZONE—See Ozone, p. 657.

OZONIDES—Combinations of ozone with unsaturated hydrocarbons and alcohols—as, for example, ethylene ozonide ($C_2H_4 + O_3$).

The ozonides formed by combination of certain acids, aldehydes, and ketones with ozone can combine with a fourth atom of oxygen, yielding perozonides, resolved by water into the ozonides and hydrogen dioxide, the ozonide atoms being viewed as attached to the two carbon atoms of the ethylene linking, and the fourth atom to the carbonyl group.

Propylene is said to yield an oxozonide product, $C_3H_6 + O_4$, and there is a benzene triozonide ($C_6H_6O_9$) of explosive nature. The ozonides are decomposed when gently heated.

E. C. Baly has described certain compounds as metallic ozonides, although they are not of a peroxidic structure. The mercury compounds produced by the action of ozone on the metal appears to be $X._n$, Hg, X being a molecule of the normal lower oxide of the metal, and n is a small integer. The ozonides of mercury, sodium, barium, zinc, cadmium, tin, lead, and bismuth are solid, have a metallic fracture, and the mercury ozonide, upon trituration in air, suffers some kind of dissociation.

***p*H VALUES**—According to Thomas and Elliott (*J.S.C.I.*, 1931, **50**, 303 T), the quinhydrone electrode has replaced the hydrogen electrode for many routine purposes. (See C. C. Coons (*Ind. Eng. Chem.* (*Anal.*), 1931, **3**, 402); C. Morton on an Automatic *p*H Recorder (*J.S.C.I.*, 1931, **50**, 436 T); *Colorimetric and Potentiometric Determination of* pH, by I. M. Kolthoff (Chapman and Hall, Ltd.); Hydrogen-ion Determination and Volumetric Analyses.)

PACHIMETER—A machine for measuring the heaviness of soils, and used in the study of flour doughs.

PACKING MATERIALS—Substances used for packing joints of pipes and utensils, such as pitch, asbestos, bitumen, etc., and a great number of proprietary and other compositions, including some special ones for use in absorption towers. (See H. Seymour (*Ind. Chem.*, 1926, ii., 301); Cement, Lutes, and Tower Fillings.)

PAINTS—Mixtures of ground white-lead, red-lead, powdered aluminium, zinc oxide, titanium oxide, zinc sulphide, asbestine, lime, china clay, calcium sulphate, barium sulphate, or other mineral bases, with boiled linseed oil and turpentine (or turpentine substitute); used to prevent the

PAINTS (*Continued*)—
rusting of iron and for the preservation of wood and other surfaces; also for artistic and decorative purposes. The oxides of antimony and titanium are also used as bases for white paints, and aluminate of lead and lead aluminate-silicate have been recently suggested as useful pigments. The manufacture and further particulars respecting white-lead are described under that heading and that of Lead Compounds (p. 525). Tests have definitely proved that a paint made with 50 per cent. barytes and 50 per cent. white-lead is more durable as a pigment than pure white-lead paint.

Aluminium paint, now extensively employed for giving visibility to lamp and electric standards and other obstacles to safe motoring, as also for decorative purposes, can likewise be used in respect of creosoted wood guard rails and fences, provided the proper vehicle is used and the wood is first allowed to dry for a time after treatment. It is also useful as a primer under house paints for wood.

The mixing of so-called aluminium paints, made from powdered aluminium and mediums such as tung oil or turpentine or spirit, is the subject of a brochure issued by the British Aluminium Co., Ltd., of Adelaide House, London.

The term pigments is in practice applied chiefly to the insoluble mineral colouring matters or blacks incorporated in paints as distinct from organic colouring matters such as dyes and stains, which may be soluble in the vehicles used. Many of them, such as carbon, iron oxides of various colours, red-lead, sienna, ultramarine, umber, vermilion, etc., are described under their respective names. Pigments have to be ground to a good commercial quality, 200 mesh being an efficient state of division. (See *C.T.J.*, 1926, **79**, 309.) (With respect to the importance of particle size of pigments see "Report of Chemical Congress" (*Chem. and Ind.*, 1926, **45**, 574); report of paper by C. A. Klein on "Applications of the Microscope" (*C.T.J.*, 1926, **78**, 285), and Particles.)

Titanium oxide pigments are more particularly referred to under that heading.

Lake pigments consisting of combinations of coal-tar dyes precipitated on inert bases such as clay, barytes, and whiting have also come largely into use of late for internal decorations.

Bituminous paints, prepared by dissolving bituminous substances in a suitable solvent (according to the application), with or without oils, resins, fillers, etc., are of special importance for many applications, as they can be easily applied in quick-drying and other solvents, of any thickness, are very adhesive, exhibit great preservative qualities and resistance to weather influences, acids, and alkalies; while their elasticity obviates cracking on iron and steel work. (See W. N. Bowran on "Bitumens as Paint Constituents" (*C.T.J.*, 1931, **88**, 379) and "Melanoid.")

It is inadvisable to use red oxide (ferric oxide) paint on chemical work where there is liability to attack by corrosive vapours; paints containing linseed oil are also better avoided, preference being given to

PAINTS (*Continued*)—
bituminous paints or others made with mineral black and an entirely volatile solvent.

Lead aluminate prepared from litharge and alumina is said to form a white pigment unaffected by hydrogen sulphide, resistant to dilute acids, and possessing a covering power equal to that of white-lead.

The use of a specially prepared silicon ester as a paint alone or for incorporation in other paints was the subject of a recent paper by G. King. (See Silicon Esters, p. 809.)

Graphite in paints into which it can be introduced acts as a preventive of water penetration. Inhibition of drying of linseed oil paints is caused by tar paints. Linseed oil boiled, air-blown, or heat-bodied takes precedence of all other oils, although tung oil after heat treatment, as also perilla oil, admits of use, and even fish oils, such as menhaden oil, find, with others, a more or less limited application.

A luminous paint of soft greenish glow and great durability is now prepared by incorporating a small proportion of radium salt or mesothorium in a zinc sulphide base (particularly the native sulphide *wurtzite,* which is very responsive to the α-rays of radium disintegration), using some good binding material such as nitro-cellulose lacquer. Other methods for preparing various luminous paints and enamels are given in the *C.T.J.*, 1925, **76,** 387; and *Ibid.*, 1928, **83,** 434.

Highly luminous mixtures used in paints and enamels are obtained by heating alkaline earths with certain proportions of sulphur, starch, lithium carbonate and traces of bismuth nitrate, rubidium nitrate, lead acetate, or other metallic salts, and a description of such compounds and their preparation is given in the *C.T.J.*, 1925, **76,** 387.

Volatile liquids, such as benzene, petrol, rosin spirit, turpentine, naphtha, and acetone, are used in paint-making as thinners or vehicles, and upon evaporation leave the boiled linseed oil and mineral base on the coated surfaces. The linseed oil or substitute absorbs oxygen from the air, and mixed with the base forms a conglomerate solid mass constituting the real paint. Turpentine differs from the other vehicles named, inasmuch as it does not volatilize so quickly, and absorbing oxygen from the air (particularly in warm weather and sunlight), forms a skin of oxidized product, thus adding slightly to the weight of the dry paint.

Titanium Oxide Paints—See Titanium Compounds.

White-lead Paint—See White-Lead and Lead Compounds, p. 525.

Enamel paints are those ready mixed with varnish, so that upon drying they leave an enamelled face or gloss.

Lithopone is a white paint pigment and filling, largely used in the rubber and linoleum industries, having zinc sulphide, zinc oxide, and barium sulphate as chief basic constituents, prepared by strongly heat-

PAINTS (*Continued*)—

ing a mixture of zinc sulphide and barium sulphate, or one of barium sulphide and zinc sulphate, to redness. X-ray analysis has shown it to be a single mechanical mixture usually containing 27 to 28 per cent. ZnS, 70 to 71 per cent. $BaSO_4$, with 1 to 1½ per cent. ZnO.

Orr's Zinc White is made from a pigment mixture of about 70 to 72 per cent. barium sulphate and 28 to 30 per cent. zinc sulphide, prepared by the double decomposition of barium and zinc salts and some subsequent treatment. It exhibits good lustre and lasting qualities, and is not very susceptible to attack by hydrogen sulphide.

The precipitated compound of zinc sulphide and barium sulphate as prepared from solutions of zinc sulphate and barium sulphide in water has but little covering power, but after heating to redness and plunged into water, ground, washed, and dried, it forms a satisfactory and durable pigment. It has a sp. gr. of about 4·25 and oil absorption 8 per cent., and is said to be the most opaque of all white pigments. A mixture of 95 per cent. with 5 per cent. of cadmium lithopone gives a nice cream-yellow product when rubbed out with oil.

The darkening of lithopone in some cases is due to the presence of contaminating metals which form dark-coloured sulphur compounds, particularly those which are susceptible to double decomposition with the light-sensitive zinc sulphide (lead, thallium, and manganese in particular, while iron, nickel, and cobalt alone are not so objectionable). Small percentages of certain salts are often incorporated to obviate this darkening, tri-sodium phosphate being, perhaps, the best. In other cases the conclusion has been reached that darkening is due to reduction of metallic zinc and probably free sulphur on exposure to light, and that the re-whitening effect experienced in the dark is due to the oxidation of the free zinc (Goshorn and Black, *Ind. Eng. Chem.*, 1929, **21**, 348).

The "Oxidation and Weathering of Linseed Oil Paints" is the subject of an article by J. D'Ans (*B.C.A.*, 1929, B, 988); notes concerning the manufacture and uses of these paints (*C.T.J.*, 1930, **86**, 327, and **87**, 18); see also "The X-Ray Examination of Lithopones," by W. A. Wood (*J.S.C.I.*, 1930, **49**, 300 T), and the light-fastness question (*C.T.J.*, 1932, **90**, 377).

Cadmium lithopone is a pigment mixture, in which the zinc of the ordinary product is replaced by cadmium and is valued on account of its rich yellow colour. (See W. Bannard (*Chem. and Ind.*, 1929, **48**, 335; *C.T.J.*, 1924, **75**, 642, and 1927, **80**, 59); "Notes on its History," by R. W. Cooper (*Chem. and Ind.*, 1927, **46**, 552); the "Lithopone Industry," by N. F. Budgen (*Ind. Chem.*, 1926, ii., 169); "Losses in Purification Process, etc." (*C.T.J.*, 1926, **79**, 143 and 174; 1927, **81**, 169; and 1928, **83**, 294); and Albilith.)

"Sulfopone" is a white pigment analogous to lithopone in which barium sulphate is replaced by calcium carbonate made by precipitation of a solution of calcium sulphide with one of zinc sulphate. It is

PAINTS (*Continued*)—

said to be superior to lithopone in covering power and behaviour on drying.

Distemper paints are compounded of bases with water and adhesives used as binders, such as size, glue, casein, etc.; casein distempers very quickly lose their adhesiveness, and should be used quickly after preparation. Antiseptics can be usefully incorporated in many distempers.

Antifouling Compositions are used for preventing the corrosion of the bottoms of iron ships and the adhesion of marine zoophytes. The paint should be waterproof, so as to exclude water from contact with the iron, and the antifouling mixture placed on top of the paint should remain entirely undisturbable. Both have to be of a quick-drying character, hence they must be of a nature that dries quickly by loss of solvent as distinct from drying by oxidation, as oil varnishes do.

For waterline protection, zinc oxide in a slightly thickened linseed oil has been found satisfactory. Copper naphthenate, it is stated, forms an excellent base for paint used to protect the hulls of ships.

Iron oxide is a common pigment that is used with or without some kind of "filler," thinned down with naphtha, but the most satisfactory products are stated to be certain pitches and asphalt solutions, with or without a little linseed oil, using iron oxide as the pigment, and tar oil as the solvent or thinning material. All kinds of gums, as well as ordinary resin, are also used in compounding more or less satisfactory varnishes for use in connection with these paints.

Of the substances incorporated to render the composition toxic to marine life, compounds of copper and mercury rank first, including cuprous oxide, emerald green, and copper carbonate, and mercury in the form of oxide, sulphide, or, better still, mercury compounds of an organic character, such as mercury dinaphthyl.

Ships' bottoms, adequately protected, can be kept in a reasonably good condition for from nine to twelve months.

J. H. Orton, as the result of an investigation lasting over some years, has reached the conclusion that in order to maintain the bottoms of ships free from growths over a period of years some other method must be used, because of the rapid disintegration of the paint-body caused by the action of bacteria. (See *Nature*, August 20, 1930.)

Aluminium stearate has found increasing use in recent years in the paint trade to increase the body and to inhibit the settling of pigments. At ordinary temperatures it is practically insoluble, but dissolves readily in hot mineral hydrocarbons, turpentine, benzol, etc., to form sols which gelate to various degrees upon cooling.

Numerous paint-spraying plants are in use for the rapid painting of extensive surfaces, such as are presented by the walls of factories, workshops, ships, bridges, and other large structures.

A mixture of equal volumes of *p*-cymene (a by-product of sulphite paper mills), ethyl alcohol, methyl alcohol, and acetone is described as an excellent (U.S.A. patent) paint remover.

PAINTS (*Continued*)—

"Tempera" paints are made either from media containing egg-yolk or others consisting essentially of emulsions of oil and water, using casein, gum, or soap as emulsifying agents. Those used in making artist's colours are referred to by P. May (*C.T.J.*, 1925, **76,** 639).

Other References: Description of American pigment installation (*C.T.J.*, 1925, **76,** 671); "Power Transmission in Pigment Manufacture," *Ibid.*, 1925, **77,** 157; "Protection of Metals by Painting," by U. R. Evans (*Chem. and Ind.*, 1930, **49,** 1078); "Some Outdoor Tests of Protective Painting," by Evans and Britton (*J.S.C.I.*, 1930, **49,** 173 T); "Scientific Aspects of Paint Technology," by L. A. Jordan (*J.S.C.I.*, 1929, **48,** 13 T); "Some Chemical and Physical Characteristics of Paint," by A. K. Light (*Chem. and Ind.*, 1926, **45,** 101 and 123); S. W. Kendall on "Modern Ball and Pebble Mill Technique" (*C.T.J.*, 1932, **90,** 191); D. G. Hopkins on "Modern Developments in the Paint and Varnish Industry" (*Chem. and Ind.*, 1932, **51,** 186); "Photometric Method of Measuring the Covering Power of Paints," by H. D. Druce (*Analyst,* 1926, **51,** 371); "Microscopic Characters of White Pigments and Extenders," by C. H. Butcher (*Ind. Chem.*, 1926, ii., 401); "Anti-corrosive Paints," by A. G. Daniels (*Ind. Chem.*, 1925, i., 271); "Heat-resisting Paints," by F. T. Walker (*Ind. Chem.*, 1928, iv., 138); "Paint-making" (*Ibid.*, 1928, iv., 324); "Application of the Microscope in Pigment and Paint Valuation" (*C.T.J.*, 1926, **78,** 285); "Paints and Enamels as Protective Coverings for Iron and Steel," by H. N. Bassett (*Ind. Chem.*, 1930, vi., 293); "Railway Painting Problems" (*C.T.J.*, 1929, **84,** 465); reviews of "Progress of the Paint and Varnish Industries in 1925," by R. S. Morrell (*Ind. Chem.*, 1926, ii., 14), and by Morrell and Wornum during 1926 to 1931 (*Ibid.*, 1927, iii., 9; 1928, iv., 8; 1929, v., 12; 1930, vi., 26; 1931, vii., 29; 1932, viii., 23); "Relation between Corrosion and Paint," by Vernon and Jordan (*Chem. and Ind.*, 1931, **50,** 1050); S. Smith on "Mixing, Grinding, and Refining of Paints and Enamels" (*J. Oil Col. Chem. Assocn.*, 1930, **13,** 163); *Blacks and Pitches*, by H. M. Langton (E. Benn, Ltd.); *The Manufacture of Paint*, by J. Cruickshank Smith (Scott, Greenwood and Son); *Outlines of Paint Technology*, by N. Heaton (C. Griffin and Co.); *Solvents and Thinners in the Paint and Varnish Industries*, by N. Heaton (Ernest Benn, Ltd.); *The Technology of Paint and Varnish,* by A. H. Sabin, third edition (Chapman and Hall, Ltd.); Colours, Driers, Gums and Resins (p. 431), Lacquers, Siccatives, and Varnishes.

"PALAN"—An alloy of gold with palladium—a substitute for platinum.

PALLADIUM (Pd) **and its Compounds**—Atomic weight, 106·7; sp. gr., 11·5; m.p. 1,545° C. Palladium is a rare metal of the platinum group of elements, and is found associated in platinum ores to the extent of from ½ to 1 per cent., the chief source being *ouro poudre,* a native alloy with gold occurring in some Brazilian mines.

The metal can be obtained by ignition of the double palladium-

PALLADIUM (*Continued*)—

ammonium chloride, and is used as an alloy with gold, silver, or copper in dentistry, also for balance wheels of watches and as a catalyst, etc. The plating of white gold and silver renders them non-tarnishable.

It is white, fairly ductile and malleable, and is especially interesting on account of its capability (particularly in the spongy condition) of "occluding" gases, including hydrogen, argon, neon, etc. If, for example, a wire of palladium be made the negative pole of a voltaic cell, it will in course of the decomposition of water absorb as much as 936 times its own volume of hydrogen gas, during which time it increases very largely in bulk. A piece of foil of the metal will, when heated to between 90° and 97° C. in an atmosphere of hydrogen, absorb as much as 643 times its own volume of that gas. One view is that the gas thus absorbed is in a state of solid solution, and that two such bodies exist; the saturated one (Pd_2H) at 80°, 160°, and 180°, and another containing more hydrogen at lower temperatures. Graham regarded hydrogen as a metallic element, and struck a special medal of an alloy with palladium stated to contain 900 volumes of hydrogen.

Palladium is readily soluble in hot nitric acid, and its compounds, which resemble those of platinum in form and general characters, include three oxides (Pd_2O, PdO, and PdO_2)—reducible to the metallic state when strongly heated—and two chlorides ($PdCl_2$ and $PdCl_4$), which are soluble in water and used in making indelible ink and photography on porcelain, etc. (See M. E. Klarman, *B.C.A.*, 1930, A, 1505, and Occlusion.)

"PALLAS"—An alloy of palladium, platinum, and gold, described as harder, cheaper, and lighter than platinum; used as a substitute for platinum in making crucibles, etc.

PALM OIL (**Palm Butter**) is chiefly obtained from the West African oil palm *Elæis guineensis* and other species, including *Cocos butyracea* and *Avoira elæis*, which grow in abundance in Sierra Leone, Lagos, Gold Coast areas, and Senegal (Nigeria being this country's principal source), while the smaller supply of South American oil comes from the analogous but smaller *Elæis melanococca*. The red palm oil of commerce comes from the pulp surrounding the kernels, and consists chiefly of the glycerides of palmitic and oleic acids, together with proportions of those of stearic and other acids and a large proportion of free palmitic acid, varying, it is stated, from 12 per cent. in the fresh to over 50 per cent. in old oil.

Palm oils, according to Hilditch and Jones, "closely resemble the tallows in their fundamental mode of assemblage" as regards glyceride structure, and the composition of commercial varieties is the subject of a paper referred to below. The oil is best removed by pressure, solvents being subsequently applied. (See A. Stieltjes, *B.C.A.*, 1930, B, 620.) It is purified by melting to remove water or refined with lye, and can be decolourized by chemical agencies. A German method of

PALM OIL (*Continued*)—

bleaching, said to give good results, consists merely of immersing a screen of very fine mesh wire cloth in a bath of the oil and heating to 100° C., the bleaching being attributed to the atmospheric oxygen adhering to the wire. It can also be bleached to some extent by means of fuller's earth or "Frankonite." Fuel briquettes are made from the waste fibre and the shells of the *Elæis guineensis*. From the Nigerian palmeries, out of a total of 21 per cent. oil, only from 8 to 11 per cent. is obtained by the native methods of extraction.

The sp. gr. of the West African supply is generally given as 0·92 to 0·93, the i.v. as 13·5, and the ref. ind. as 1·4510 at 60° C. According to one account, the following are the constants of the two supplies above referred to:

	West African.	South American Noli Palm Oil.
Sp. gr.	0·8586	0·8636
Solidification point	36°-46°	33·6°
Saponification value	196-205	199
Iodine value	53-57	83·5

Palm oil varies in colour from orange-yellow to dark dirty red; it contains the fat-soluble vitamin A, and has a consistence varying from that of butter to that of tallow, varieties being known as soft, hard, and mixed oils, according to the originating districts. It is subject to enzymic hydrolysis during storage, and is extensively and variously used in making margarine, soap, and candles, as a lubricant, also in the tin-plate industry, and (in admixture with tallow and some proportion of alkali) as railway-waggon grease.

The fruit is stated to yield approximately 37·5 per cent. pulp and 62·5 per cent. seeds, the 37·5 per cent. pulp being made up of 32·8 per cent. of palm oil, the remaining 4·7 per cent. being water and waste fibre; while the 62·5 per cent. seeds consists of 47·92 per cent. shells and 14·58 per cent kernels, which contain about 50½ per cent. of fat. The fleshy part of the fruit contains about 58½ to 66½ per cent. oil. The kernels of the West African oil palm contain about 50 per cent. of white fatty oil; those of the East African palms and of the South American fruit contain about 29 per cent. of oil, equal to 31·5 per cent. in the desiccated fruit.

The crude palm-nut or kernel oil is yellowish, fat, and edible, and is obtained by crushing and pressing the kernels or extracting the oil from the crushed material by solvents. It consists of the glycerides of palmitic, stearic, oleic, myristic, lauric, caprylic, capric, and linoleic acids; is practically devoid of free fatty acids, and is soluble in alcohol, carbon disulphide, and ether. E. F. Armstrong (with others) give the composition of the fatty acids from palm-kernel oil as follows: lauric acid, 52 per cent.; oleic acid, 16 per cent.; myristic acid, 15 per cent.; palmitic acid, 7·5 per cent.; caprylic acid, 3 per cent.; capric acid, 3 per cent.; stearic acid, 2·5 per cent.; and linoleic acid, 1 per cent. (See

PALM OIL (*Continued*)—

J.S.C.I., 1925, **44,** 144 T). Its sp. gr. is generally given as 0·925, but the communication already referred to (p. 666) gives the constants as follows:

	West African.	Noli Palm Oil.
Sp. gr.	0·8731	0·8651
Solidification point	20°-25·5°	26·9°
Sap. v.	242-255	234
I.v.	10·3-17·5	27·7

while Hilditch and Jones give the characteristics of certain palm oils studied by them as sap. v. varying from 280·2 to 283·8; i.v. ranging from 52·7 to 57·3; ref. ind., n_D^{60}, 1·45° to 1·142°.

The kernels of the South American fruit contain 45·4 per cent. oil (equal to 48·7 per cent. in the desiccated seeds), used in soap-making, chocolate articles, and in pharmacy. The dry kernels of Curua palm oil (*Attalea spectabilis*) from Brazil yield 65·3 per cent. of semi-solid, greenish oil of sp. gr. 0·8693; ref. ind., 1·447; m.p. 23·6° C.; sap. v., 259·5; and i.v., 8·9.

Guere palm nuts from Columbia, from a species of *Astrocaryum* (*A. Tucuma*, Mart.), have yielded 37·6 per cent. pale cream fat, m.p. 35·5° C.; sp. gr. 100°/15° C., 0·864; sap. v., 349·6; and i.v., 9·4.

Palm oil from the Belgian Congo is reported by Jamieson and McKinney as having sp. gr. at 25°/25° 0·9146; n_D^{40} 1·4578; acid v. 20·6; sap. v. 197·9; i.v. (Hanus) 53·7, etc.; and percentages of the different glycerides present as: oleic 47·2; linolic 5·6; myristic 0·5; palmitic 40·8; stearic 5·2; and lignoceric 0·1 (*Analyst*, 1929, **54,** 477).

It has been reported that among French West African oil palms one specimen gave 73·6 per cent. pulp in the fruit, 53·3 per cent. oil from the pulp by ether extraction, and 40·8 per cent. fat from the whole fruit by ether extraction. The African oil palm of the Gold Coast yields 77 to 80 per cent. oil calculated on the dry pulp, whereas the same species grown in Ceylon only gives about 66 to 69 per cent.

Palm-kernel cake is a useful cattle foodstuff, and contains usually about 16 per cent. protein.

Subject to further trials, there is some chance of the oil-palm fibre being successfully employed in competition with the finer counts of flax, etc., for manufacturing purposes.

(See "Chemistry of Palm Oil," by W. Brash (*J.S.C.I.*, 1926, **45,** 438 T); A. Rayner (*Ibid.*, 1927, **46,** 160 T); "Component Glycerides of Palm-Kernel Fat," by Collin and Hilditch (*J.S.C.I.*, 1928, **47,** 261 T); "Composition of Commercial Palm Oils," by Hilditch and Jones (*J.S.C.I.*, 1930, **49,** 363 T and 369 T, and 1931, **50,** 171 T); H. M. Langton on the industry (*Chem. and Ind.*, 1928, **47,** 655; *Ind. Chem.*, 1931, vii., 71); "A Modern Palm Oil Plant," by J. W. Sewill (*Ibid.*, p. 511); E. E. Jones (*Chem. and Ind.*, 1932, **51,** 269); also Table, p. 635.)

PALM WAX—See Waxes.

PALMAROSA OIL—See Geranium (Turkish) Oil.

PALMETTO—A tannin material (yield 25 per cent.) from the *Sabal serrulata* (the American palmetto palm) of Florida and Georgia.

PALMITIC ACID ($C_{16}H_{32}O_2$)—A member of the normal fatty acid series and a constituent of most of the harder fats, including spermaceti, and especially palm oils. It is tasteless, odourless, soluble in hot alcohol and ether, and is obtained in crystals of sp. gr. 0·8465 and m.p. 63·4° C. Can be distilled at reduced pressure without change, and when saponified with alkalies forms hard soaps. (See Fats.)

PALMITIN ($C_3H_5(C_{16}H_{31}O_2)_3$)—A white crystalline fat, m.p. 65·5° C. (See Fats.)

PANCREATIC JUICE—A secretion of alkaline reaction, containing pancreatine and other enzymes which assist in completing the digestion of substances in the chyme and emulsifying fatty bodies also present therein. When agitated with neutral oils, pancreatic juice makes perfect emulsions, and this emulsification enables the fatty matters to pass through the pores of the mucous membranes into the chyle ducts. In common with saliva it also has the property of converting starch into sugar. (See Enzymes.)

PANCREATINE—See Enzymes and Pancreatic Juice.

"PANDERMITE" ($3CaO,4BO_3,6H_2O$)—A trade name for mineral amorphous calcium borate (sp. gr., 2·26); used in compounding ceramic frits; its composition has also been represented as $4CaO,5B_2O_3 \times H_2O$.

PAPAIN—See Enzymes.

PAPAVERINE—See Opium.

PAPER may be described as a fabric made by the deposition of finely divided fibres from a state of suspension in water by means of a sieve or strainer, followed by rolling and calendering. There are many varieties, including those made for newspapers and ordinary printing, writing papers, wrapping and packing papers, and a great number of miscellaneous characters. The paper is spun by steaming the pulp mixture over a wire cloth, thus forming a continuous sheet, which is afterwards pressed between hot rollers, thus drying and at the same time polishing it. Over 90 per cent. of the world's paper is now made from wood cellulose in varying states of purity.

It was made almost exclusively from rags down to 1866, but in that year esparto grass was first employed, and since then cotton, flax, hemp, rhea (ramie), jute, linden bast, adonsonia bast, sisal hemp, yucca, hibiscus, New Zealand flax, aloe, common nettle, phormium, broom, caroa fibre, paper mulberry, straws, and wood pulp have been very extensively used in its manufacture, as also the cellulose made from the bamboo and Savannah grasses; in point of fact, any fibrous vegetable matter can be turned into paper if properly treated, although grasses are not so tractable.

Chemically pure rag paper is generally supposed to be the best for use in respect of documents calling for the greatest preservation, and

PAPER (*Continued*)—

Colombian Pita, a fibre of great strength and durability, gives a paper said to be unequalled by any other material. While it is generally understood that the best grades are those made from cotton and flax, by reason of certain physical properties enabling close interlocking of their fibres and thus promoting resistance to handling, that made from esparto grass has better durability than paper made from chemical wood. The acid ("sulphite") process fails to remove certain adventitious deleterious constituents associated with the cellulose, while the alkaline process produces a pulp possessing a better degree of permanence. These processes are described later; the views above expressed being gathered from a letter to *The Times* of December 8, 1930, by J. Eddington Aitken.

Cellulose is not present in the free state in plants, but is always in admixture or combination with other groups, such as lignin, fats, waxes, colouring matters, tannins, acid derivatives of carbohydrates, etc.

"Mechanical pulp" consists chiefly of ligno-cellulose, and no attempt is made to remove the resinous and other associated substances. It is produced by cutting up the logs of wood into certain lengths after removal of the bark and grinding in water in a longitudinal direction under pressure by a rotary grindstone. The product is then strained and made up into sheets by passing it over a rotary wire mesh, partially dried and pressed by a rolling process and then shipped with a content of about 50 per cent. water. This mechanical pulp used in admixture with from 20 to 60 per cent. of "sulphite" pulp is used for the cheaper qualities of printing papers and news-print.

In the "soda process" of preparing cellulose for paper-making from wood (which is the one employed most extensively), spruce, pine, larch, birch, and poplar (which vary in their constituent proportions of cellulose and lignin) are employed with or without the incorporation of rag pulp. To prepare the wood pulp the bark is removed, and after cutting up into small pieces, the wood is heated in a strong solution of caustic soda under some pressure, in which process the lignose-cellulose and other associated bodies are dissolved and the cellulose remains undissolved. It amounts to about one-third of the original weight, and after washing to free it from associated soda the pulp is ready for bleaching.

In the "sulphite-digestion" process (by which the greater bulk of the world's paper is produced) the wood chips or wood pulp is boiled under pressure of from 50 to 100 lbs. in a solution of calcium bisulphite, $Ca(HSO_3)_2$, or magnesium bisulphite, made by passing a current of sulphur dioxide through milk of lime or magnesia. This renders the non-cellulose parts soluble, the yield of cellulose being influenced by the temperature (varying from 125° to 155° C.) and the percentage of lime or magnesia on the weight of wood, and when that is excessive more sulphur dioxide is required to complete the digestion; but in general 48 to 55 per cent. of the wood is obtained as cellulose of good enough character to use for paper-making. (See Miller and Swanson (*J.S.C.I.*, 1925, **44,** 842); E. Hägglund (*B.C.A.*, 1926, B, 911, and

PAPER (*Continued*)—

B.C.A., 1929, B, 201); and *Papier-Fabr.*, 1926, Vol. 24, pp. 449-450 and 483-488, abstracts.)

Parchment paper is produced by dipping paper into sulphuric acid of about 50 per cent. strength, whereby it is partially hydrated and gelatinised, after which it is washed free from the acid and carefully dried.

Reverting to the "soda process," in the case of rags, esparto, and other grasses, cleaning, cutting, boiling, bleaching, and beating operations succeed each other, and when by these operations foreign matter has been removed and disintegration of fibres secured, comes the chemical process of boiling with alkali, caustic soda solution (reinforced at times with sodium carbonate) being usually employed to remove contaminating materials such as fat, resin, gum, starch, china clay, or other loading material.

The bleaching of pulp is effected by the use of either bleaching-powder solution, sodium hypochlorite, or sulphur dioxide, and when chlorinating preparations are used, any excess of chlorine is removed by the use of an "antichlor," such as sodium thiosulphate, before the sizing operation.

When the pulp, after washing, has been sufficiently beaten in order to separate the individual fibres, size is added to give the paper water or ink resisting qualities, mineral matter added to load up the pores of the paper, and colouring matter if desired. The mineral matters so used include china clay, talc, chalk, witherite, and calcium sulphate; while umber, ochre, and red oxide are among the colouring materials employed.

Sizing, when required, is effected either by adding resin or sodium resinate to the pulp, and afterwards adding alum solution or dilute sulphuric acid so as to fix it in the body of the paper; or the spun paper is passed through a bath of gelatin solution and then through one of alum solution to precipitate the gelatin in the pores of the paper. Or instead of using resin for sizing, soap solutions can be used, particularly the alkali salts of stearic acid, alone or in conjunction with sodium silicate, alum being used as the precipitant. Sodium silicate alone or with starch is also used, and it helps to retain and cement short fibres in the sheet. So-called "colloidal resin," for use in sizing paper pulp, is prepared by dissolving it in alcohol, and then diluting the solution with water, so making an emulsion, which becomes an effective sizing material when subsequently coagulated by the addition of aluminium sulphate.

The published analysis of an English clay used as a filler is as follows: Silicon, 45·92 per cent.; alumina, 38·43 per cent.; ferric oxide, 0·71 per cent.; lime, 1·18 per cent.; magnesia, 0·21 per cent.; alkalies (K_2O), 0·78 per cent.; total water, 12·77 per cent.

The dyeing of paper is carried out by precipitating the colouring matter directly on to the prepared pulp or indirectly by dissolving it in boiling water to which a little ammonium or acetic acid is added (according to the nature of the dyestuff) and mixing with the pulp in the beating machine. (See *L'industrie Chimique*, March, 1923.)

PAPER (*Continued*)—

By the "Ramar" process of pulp-making, the wood, or grass, or other material is cooked in a dilute solution of sodium nitrate and heated at a pressure of about 100 lbs. per square inch, whereby the intercellular binding material—distinct from the lignin—is reduced to a friable and insoluble condition, and this is subsequently reduced to such a state of disintegration as to pass through the meshes of a wire-covered drum. It can thus be removed if required, but for many purposes this is unnecessary, and if left in, pulp yields of 95 per cent. and more can be obtained. (See *C.T.J.*, 1926, **79**, 529.)

There is an electrical process for preparing pulp from broken wood by exposing it in a bath of sodium chloride to a current of chlorine at 126° C.; hypochlorous acid and caustic soda thus produced acting collectively, and a chlorine process based upon the method advocated by Cross and Bevan for preparing cellulose free from lignin. (See Cellulose.)

The sulphite liquor resulting from paper-making can be utilized for alcohol manufacture, also for the preparation of a useful adhesive, and from the soda liquor an activated carbon can be made by incineration of the by-product following upon the recovery of the soda. It is also used in Sweden for road-watering, thus binding dust and making the track smooth and solid. (See R. W. Griffith (*B.C.A.*, 1931, B, 106).) An apparatus for concentrating this liquor is described by R. W. Miller (*Chem. and Ind.*, 1930, **49**, 1070). "Modern Soda Recovery in Pulp Mills" is the subject of an article (*Ind. Chem.*, 1929, v., 463), and another by E. R. Chrystall (*Ibid.*, 1931, vii., 372).

A process for the use of asphalt mixed with clay and water is in use in California for strengthening and waterproofing heavy papers and boards, the mixture being intercalated between layers of the prepared pulp. Further details about chemicals used for waterproofing paper are given by "Omega" (*C.T.J.*, 1929, **84**, 118).

The addition of rubber latex to paper pulp gives the resulting paper remarkable strength and waterproof character, and it does not crack upon folding; but doubt has been cast upon the lasting effects of this addition owing to subsequent oxidation and resinification.

The de-inking of paper is carried out by the use of strong alkaline solutions to dissolve the varnish and set free the carbon, which is subsequently removed by the use of some finely divided colloidal agent of the nature of clay or talc. The natural clay, known as Bentonite, is said to be an efficient agent of this class, being of detergent character.

"Kraft" is a high-strength paper made from wood cooked with a mixture of caustic soda and sodium sulphide; it is used in making sacks for carrying plaster, cement, etc., and some details of its manufacture are given by C. H. Butcher (*C.T.J.*, 1930, **87**, 633); see also Hägglund and Nyman (*B.C.A.*, 1932, B, 96).

It is stated that yarn is now prepared in Germany on a large scale from paper. The total production of bleached cellulose per annum has been estimated at 900,000 tons, and the total British production of paper of all kinds in 1930 is given as 1,400,000 tons.

PAPER (*Continued*)—

Papier-mâché consists of mashed or pulp paper pasted together, sometimes mixed with other substances, which admits of varnishing or lacquering or inlaying with mother-of-pearl, etc.

Special varieties of paper are made from gelatine (see Gelatin), and there are transparent kinds made from cellulose, the manufacture of one such being described in British Patent No. 300,477 (1929), and an abstract of which is given in *Ind. Chem.*, 1929, v., 217. It is made from viscose, or cellulose dissolved in cuprammonium solutions.

Other References: "Cellulose for the Paper Industry," by J. Strachan (*C.T.J.*, 1929, **85,** 556); "Correlation of Bursting Strength and Tensile Strength of Paper," by J. Strachan (*Chem. and Ind.*, 1930, **49,** 346); R. F. Stewart on "The Application of Continuous Methods of Operation to Causticing by the Lime-Soda Method" in a Kraft Pulp-Mill (*Ind. Chem.*, 1930, vi., 194); R. J. Marx on "Whitewater in Paper and Pulp Mills, and its Utilization" (*Chem. and Ind.*, 1930, **49,** 1057); "Paper Loadings," by J. S. Remington (*Ind. Chem.*, 1926, ii., 430); "The Importance of Hydrogen-ion Concentration in Paper and Pulp Manufacture," by H. T. S. Britton (*Ind. Chem.*, 1928 iv., 49); "The Quantitative Determination of Cotton, Linen, and Wood Fibres in Paper Pulp," by W. Dickson (*Analyst,* 1925, **50,** 317); "By-products Recovery in Pulp Manufacture," by J. L. A. MacDonald (*C.T.J.*, 1927, **81,** 27); "Some Lesser-Known Paper-making Fibres," by J. S. Remington (*Ind. Chem.,* 1929, v., 115); the "Rinman" utilization of soda pulp waste (*C.T.J.*, 1928, **83,** 237); "Manufacture of Paper" (*Ind. Chem.*, 1925, i., 529); C. F. Cross on "The Pulp and Paper Industry of Canada" (*Chem. and Ind.*, 1927, **46,** 381); J. Strachan (*C.T.J.*, 1929, **85,** 519); *A Textbook of Paper Making*, by Cross and Bevan (E. and F. Spon, Ltd.); Sutermeister's book on *The Chemistry of Pulp and Paper Manufacture* (Chapman and Hall, Ltd.); *The Digestion of Grasses and Bamboo for Paper-Making*, by W. Raitt (Crosby Lockwood and Son); *Practical Paper-Making,* by R. H. Clapperton (Crosby Lockwood and Son); Alfa, "Cellophane," Cellulose, Millboard, Silk Substitutes, Wood, and Wool.

PAPYRUS—Name of a genus of aquatic sedge plants of the N.O. Cyperaceæ, from the pith of which the paper of the Egyptians was made.

PARA-AMIDO-PHENOL—See Amino-Phenols.

PARA COMPOUNDS—Substitution products derived from benzene in which the substituting radicals or groups are constitutionally placed in certain definite (1-4) positions in the benzene nucleus—para-cresol, for instance. (See Benzene Ring.)

PARACHOR—See Chem. Soc. Annual Reports, 1927, **24,** 15, and 1929, **26,** 31; Cavell and Sugden on "The Parachor and Chemical Constitution" (*J.C.S.*, 1930, p. 2572); A. Sippel on "The Division and Calculation of the Parachor" (*B.C.A.*, 1930, A, 1349); *The Parachor and Valency*, by S. Sugden (G. Routledge and Sons, Ltd.).

PARA-COUMARONE RESIN—See Coumarone Resin.

PARA-CRESOL—See Cresol.

PARA-NITRANILINE—An intermediate. (See Nitranilines.)

PARA-NITROPHENOL—See Nitro-Phenol.

PARA-PHENYLENE DIAMINE ($C_6H_4(NH_2)_2$)—A colourless crystalline intermediate, soluble in water, alcohol, and ether.

PARAFFIN OIL—A general name given to a number of hydrocarbons heavier than kerosene, of flash-point from 300° to 450° F., variously derived from the distillation of wood, coal, lignite, peat, shale, petroleum, etc. There are varieties of yellowish, brown, red, or green colour, used for lubricating purposes and in leather-dressing, etc., a refined quality of high-boiling character prepared from petroleum being used in medicine. (See "Nujol," Petroleum, and Vaseline.)

PARAFFIN WAX—See Waxes.

PARAFFINS—See Hydrocarbons and Petroleum.

PARAFFINUM LIQUIDUM, B.P.—A pharmaceutical preparation, being a mixture of hydrocarbons of the methane series, of sp. gr. 860 to 890, and b.p. above 360° C.; used as an internal lubricant, also as a vehicle for oily spray solutions containing menthol, thymol, and volatile oils.

PARAFORM or **PARAFORMALDEHYDE,** $(CH_2O)_2$, is a white substance soluble in hot water, constituting a polymeric form of formaldehyde (CH_2O), and when volatilized it passes back again into that form. Its disinfecting power in vaporous form is identical with that of formaldehyde. (See Formaldehyde and Fumigation.)

PARALDEHYDE or **PARA-ALDEHYDE** ($C_6H_{12}O_3$)—A water-white liquid of pleasant odour, being a polymer of acetaldehyde; used as a soporific and hypnotic; sp. gr., 0·9943, and b.p. 124° C. The commercial product *d* 0·940 to 0·995 has a calorific value of about 6,000 calories, and may be used as a liquid fuel in place of denatured alcohol in lamps, etc. (See Aldehydes.)

PARCHMENT—Made from sheepskins by liming in order to kill the roots of the wool and to effect its easy removal by plucking, after which they are again limed, fleshed, and the fat removed by scraping, and subsequently split in order to separate the outer skin from the inner one, which, after some further treatment, ultimately becomes parchment. The outer skin, or "skiver" (as it is known), is tanned into light leather and used for bookbinding and lining hats and shoes. (See P. Arup on "Composition of Vegetable Parchment used for Packing Dairy Products" (*Analyst*, 1931, **56,** 149).)

PARCHMENT PAPER—See Paper, p. 670.

PAREIRA ROOT (*Chondodendron platyphyllum*), used in medicine, yields alkaloids, one of which is named *iso*chondodendrine, of the composition $C_{18}H_{19}NO_3$. These alkaloids are different from those obtained from the bark of *Nactendra Rodiœi,* one of which is named *iso*bebeerine.

"PARIS BLUE"—A blue compound obtained by heating aniline with chloride of tin; used in ink, paint, and varnish making, and for dyeing.

"PARIS GREEN"—See Copper Compounds, p. 240.

"PARIS WHITE"—Good brands of whiting.

PARKER PROCESS for Rust-proofing—See Rust, p. 782.

PARSLEY (HERB) OIL, distilled from *Apium petroselinum,* N.O. Umbelliferæ (yield 0·43 per cent.), is colourless or tinged yellowish-green; of sp. gr. 1·07; soluble in alcohol and ether, and used in medicine. Parsley seed oil is yielded to the extent of about 3 per cent. and contains about 65 per cent. total fatty acids, including some oleic and linoleic acids. (See Hilditch and Jones (*J.S.C.I.*, 1927, **46,** 174 T), J. van Loon (*B.C.A.*, 1927, A, 853); Steger and J. van Loon (*Analyst,* 1929, **54,** 177); and Apiol.)

PARTICLES (Size Measuring)—See papers by P. Lukirsky and M. Kosman (*J.S.C.I.*, 1927, **46,** 21 T); G. M. Crowther (*J.S.C.I.*, 1927, **46,** 105 T); *C.T.J.*, 1927, **81,** 517; G. Martin (*B.C.A.*, 1929, B, 154); G. J. Pokrovski (*Ibid.*); F. Krezil (*B.C.A.,* 1931, A, 678); and W. L. Gadd (*B.C.A.,* 1931, B, 825); also Paints and Ultra-centrifuge.

PASSIVITY—A term indicating the corroded or other state of a substance under which it fails to exhibit its normal chemical activity—*e.g.*, some metals, such as cobalt, chromium, iron, and nickel, after treatment with oxidizing agents like nitric acid. (See U. R. Evans (*J.C.S.*, 1927, p. 1022; *Ibid.*, 1929, p. 92); Evans and Stockdale (*J.C.S.*, 1929, p. 2651); Bannister and Evans (*J.C.S.*, 1930, p. 1361); U. R. Evans (*Ibid.,* p. 478; *J.S.C.I.*, 1930, **49,** 66 T and 92 T); A. M. Hasebrink (*B.C.A.,* 1929, A, 146); Müller and Konopicky (*B.C.A.*, 1929, A, 1241); Britton and Evans on "A Comparison between the Penetrating Powers of Anions" (*J.C.S.*, 1930, p. 1773); E. S. Hedges (*Chem. and Ind.*, 1931, **50,** 750); Corrosion and Rust.)

PASTEURIZATION—See Milk.

PASTURE—Mixed grasses, clovers, and other leguminous plants for grazing. (See Vegetation.)

PATCHOULI OIL—Sp. gr., 0·950 to 0·995 at 15° C.; opt. rot., −50° to −68° at 20° C.; and ref. ind., 1·504 to 1·520 at 20° C. An essential oil derived to extent of 1·5 to 4 per cent. from the leaves of the herb *Pogostemon patchouli,* N.O. Labiatæ, indigenous in Northern India and China, and grown in the West Indies, Java, and the Straits Settlements. It contains from 40 to 45 per cent. cadinene together with eugenol and cinnamic aldehyde, is yellowish and somewhat thick, is soluble in alcohol and ether, and used in perfumery.

PATENT LAW AND PRACTICE—See book by A. W. Griffiths (Steven and Sons, Ltd., Chancery Lane, London); address by H. Levinstein (*Chem. and Ind.*, 1929, **48,** 980); address by F. L. Pyman (*C.T.J.*, 1930, **86,** 265); and memorandum on British Patent Law Reform from chemical point of view (Brit. Chem. Manufacturers' Association, 166, Piccadilly, London, W.). (See also Legal Matters.)

PATINA—See Copper, p. 238.

PATRONITE—The Minasagra deposit in the Junin Department of Peru, consisting of mixed hydrocarbons and vanadium sulphide, containing about 20 to 26 per cent. vanadium and about 60 per cent. sulphur, being the present chief source of vanadium. (See Vanadium.)

PEA-NUT OIL—See Arachis Oil.

PEARL ASH—An American crude potassium carbonate prepared from wood ashes by concentrating the lixiviate until the less soluble salts have crystallized out, then evaporating the mother-liquor to dryness and calcining the residue. It is used in glass and soap making, etc.

PEARLS are secretions of certain shell-fishes such as the pearl oyster, having a sp. gr. of 2·5 to 2·75, and consist of calcium carbonate radially interstratified with certain membranes resulting from chemical changes, to a contamination of which the occasional loss of lustre is probably due. The chief fisheries are in the Persian Gulf, Ceylon, and Lower California.

When calcium carbonate is precipitated in the presence of gelatin in thin layers, a deposit of a nacreous (pearly) structure is obtained, which becomes opaque upon prolonged drying at 50° C., just as mother of pearl or pearl itself "dies," and this fact is supposed to support the accepted views as to the physical and chemical constitution of these substances.

So-called artificial pearls have been produced by the Japanese by a method of artificial stimulation of the oyster, and this is to be regarded as a modification of the natural formation; but two French chemists (L. Clément and C. Rivière) have, it is stated, succeeded in synthesizing pearls by a purely chemical process as follows: a solution is made containing 80 per cent. water, 5 parts gelatin (in place of the albuminoid material contained in natural pearls), and 15 parts of a calcium salt, such as the lactate. After filtering hot, the object is coated with this solution and slowly submitted to the action of a precipitated solution containing sodium carbonate, trisodium phosphate, and gelatin, the gelatin being thus deposited as a very fine network; these conditions secure the required iridescence, layers of nacreous material being built up in concentric spheres, but not in radial form as in the natural pearl, which still remains unrivalled.

Methods for the detection of artificial pearls are given in abstract in the *Analyst*, 1926, **51**, 53.

A so-called "pearl essence," consisting of brilliant crystalloids, can be prepared from the scales, swimming bladders, and other integuments of certain fish. (See Mother of Pearl.)

PEAT—A carbonaceous deposit occurring in fen and marshy areas, resulting from chemical changes affecting the mossy and other plants which abound therein, often found in beds of from some inches to many feet in thickness, and containing, when dry, from 24 to 30 per cent. of carbon. "The Rôle of Micro-organisms in Peat Formation and Decomposition" is the subject of a paper by Waksman and Stevens

PEAT (*Continued*)—

(*B.C.A.*, 1929, B, 965), and one on "The Composition of Peat-forming Plants and Varieties of Peats," by Stadnikov and Baryscheva (*B.C.A.*, 1930, B, 308).

When air-dried, it forms a valuable fuel, and when coked in ovens or distilled, it yields many valuable products allied in character to those derived from lignite and coal.

The percentage of water in peat, as it occurs in a drained bog, varies from 85 to 90, and this can be reduced by warming to the boiling-point of water or blowing steam through it and mechanical pressure to from 35 to 50 per cent. Using Somerset peat and cold pressure of nearly 800 lbs. per square inch, the percentage is only reduced to about 75. The "ten Bosch process" for removing water from peat prior to its conversion into briquettes is conducted by submitting it to steam at 140° to 160° C. under the necessary pressure, and then subjecting it to mechanical pressure, thus reducing the water content to about 25 per cent.

Centrifuges have been tried for the extraction of water with incomplete success, the "Gee" centrifuge proving the best.

It is stated that by use of the so-called electro-osmose filter, 85 parts of water can be easily removed from hydraulically mined peat containing only 5 parts of the dry substance in 100 parts of suspension, so that where water-power is available to produce electricity sufficiently cheap, and peat beds are near enough and thick enough, this process of drying holds out great promise. When the electric current is passed through the aqueous mass, the peat collects in a more or less dry state on the positive pole in a compact form.

F. M. Perkin prepared peat briquettes containing only 18 to 20 per cent. water by macerating the peat, extruding as much water as possible, then exposing the mass in an autoclave under pressure to produce a sudden rise of temperature and discharging suddenly. Some briquettes made from Argyllshire peat in this way had a sp. gr. of 1·29 and calorific value 8,558 B.Th.U., contained volatile matter 51·41 per cent., water 15·12 per cent., fixed carbon 31·97 per cent., mineral matter 2·50 per cent., nitrogen 2·66 per cent., and sulphur 0·27 per cent.; and he claims that it is "now possible to produce peat commercially at a price much lower than that of coal." These briquettes are stated to produce a good charcoal suitable for the steel industry, and decolourizing applications as well as a high yield of fuel and other oils, constituting also a smokeless fuel. (See *C.T.J.*, 1925, **77**, 295.)

Another peat-drying process is known as the "Peco."

The average calorific value for Irish air-dried peat is about 6,850 B.Th.U. per lb., and its ash content is 3 per cent. The nitrogen content increases from the surface (1 per cent.) downwards (to 2·5 per cent. at the bottom of deep bogs), and it is calculated that it should yield about 100 lbs. of ammonium sulphate per ton of air-dried peat. Its main uses, however, at present are as litter, cattle food, and fuel, the last named including the various distillation products. It also has value as a fertilizer by reason of its nitrogen content, the black decom-

PEAT (*Continued*)—

posed qualities being best for such use, and it has been recommended as a useful material for softening boiler-feed water.

To be of use for carbonization, it is stated that peat must not contain more than 20 to 25 per cent. of moisture or 5 per cent. ash, and it then yields 30 per cent. gas, 5 per cent. tar, and 0·25 per cent. ammonia at a retort temperature of 1,100° C.

A block of peat upon carbonization shrinks, but maintains its integrity fairly well to the end.

The incomplete combustion of peat in a gas-producer yields some proportion of volatile oils and wax (resembling the Montana wax of lignite), a soft pitch being left behind. The volatile oils contain a proportion of phenolic bodies of an acidic character allied to those yielded by the distillation of blast-furnace tar—that is to say, of a higher germicidal character than ordinary coal-tar distillates. The calorific value of dry turf is said to be about half that of coal.

Wet peat from an undrained bog contains about 8 per cent. dry material and 2·8 per cent. charcoal, while a well-drained bog gives a peat of which 100 tons will yield about 3·5 tons of charcoal. Coke from peat can be made soft or hard at will, harder, it is said, than coke-oven coke, and of sp. gr. from 0·75 to 1·4, some qualities being exceptionally valuable for iron-smelting and for hardening steel.

It has been estimated that in Ireland the peat contained in the bogs amounts to more than ten times the *proved* coal reserves of that country. Humoceric acid ($C_{19}H_{34}O_2$) is the name given to a colourless, crystalline body isolated from peat by Ossian Aschan. The lignin content of peat is stated to decrease with age, together with a corresponding increase in the humic acids content. (See Humus and Dopplerite.)

It is possible to obtain alcohol from peat by a fermentation process, and the peat pulp can also be made into paper.

From investigations made, it is believed that in Ontario peat can be made commercially to compete with anthracite.

Other references: For the results of an examination of various groups of peat by the methods of foodstuffs analysis, see A. P. Dachnowski (*Analyst*, 1925, **50**, 304); Donnelley and Reilly on "The Low-Temperature Carbonization of Peat" (*B.C.A.*, 1930, B, 647); peat, peat drying, and peat utilization considered at the World Power Conference in 1928 (see *Chem. and Ind.*, 1928, **47**, 1028); D. Brownlea on "The Canadian Government Peat Report" (*Ind. Chem.*, 1926, ii., 355).

PECAN (Hicoria pecan) OIL—See Jamieson and Gertler (*B.C.A.*, 1929, B, 987).

PECTINS and PEPTIC ACID—The pectins are polysaccharoses, closely related to the sugars, mucilages, and gums, and occur in many fruits such as apples, pears, and grapes, also in carrots, turnips, beans, many root organs, and the tissues of numerous plants including the seeds of oranges, grape fruit, etc., reaching their maximum during the process of ripening, and then diminishing as the fruit (apple, for instance) becomes over-ripe. The dried pulp of sugar-beet contains about 25 per cent. pectin.

PECTINS AND PEPTIC ACID (*Continued*)—

They are soluble bodies derived from pectose, an insoluble intercellular substance (possibly a derivative of cellulose), the conversion taking place during the ripening of fruit, instanced also in the retting of flax, and attributed to the direct action of an enzyme termed pectinose. By the action of another enzyme named pectase, the pectins are resolved into pectic acids, the calcium salts of which give fruit juices the property of jellifying. Peptic acids are also produced from pectins and pectose by boiling for some hours with dilute alkali solutions. Pectinogen is described as the methyl ester of pectic acid.

The different pectins are hydrolysed by boiling with dilute mineral acids into the saccharoid bodies, *d*-galactose and *l*-arabinose; and by dilute sodium hydroxide, forming the sodium salt of pectic acid. Chemically, they probably consist of the di-methyl-isopropenyl esters of pectic acid. They appear to have a ring complex containing galacturonic acid ($CHO.(CHOH)_4.CO_2H$), a compound which, when distilled with hydrochloric acid, breaks up into furfurol and carbon dioxide: $C_6H_{10}O_7 \longrightarrow C_5H_4O_2 + CO_2 + 3H_2O$. The pectins are responsible for the formation of jelly in making jams and preserves, and apple pectin is used for thickening jam.

Pectin is precipitated as a jelly on boiling and by the action of acids.

The "Bloom Gelometer" is a device for measuring the jelly-strength of fruit jellies. (Fellers and Griffiths, *B.C.A.*, 1928, B, 727.)

The formula $C_{17}H_{22}O_{16}Ca$ has been assigned to calcium pectate.

References: A Critical and Historical Study of the Peptic Substances of Plants, by M. H. Branfoot (M. H. Carré) (issued in respect of Food Investigation (Report No. 33) Dept. of Scientific and Industrial Research, obtainable at Adastral House, Kingsway, London, W.C. 2), in which pectin is represented as a neutral methoxy-ester of pectic acid containing 11·76 per cent. of methyl alcohol, and pectic acid is viewed as a complex galacturonic acid combined with arabinose and galactose. The manufacture of fruit jellies is also taken into consideration in this report. (*Analyst*, 1929, **54,** 594; abstract of paper by G. Spencer on "Formation of Pectin Jellies" by sugar, from *Journ. Phys. Chem.*, December, 1929 (*Ind. Chem.*, 1930, vi., 39); S. Glückmann (*B.C.A.*, 1931, A, 683); Ehrlich and Schubert on "Pectin Substances" (*B.C.A.*, 1929, A, 1273); E. K. Nelson (*Analyst*, 1926, **51,** 582); "The Extraction and Utilization of Pectose," by Paul and Grandseigne (*B.C.A.*, 1929, B, 734); "The Rôle of Pectin," by Myers and Baker (*B.C.A.*, 1931, B, 220); "Pectin" (*Ind. Eng. Chem.*, October, 1925, p. 1065); *C.T.J.*, 1925, **77,** 568; G. W. McKinney (*J.S.C.I.*, 1926, **45,** 301 T); and F. W. Norris (*Chem. and Ind.*, 1929, **48,** 292); also Pectose.)

PECTOGRAPHS—Deposits from colloidal solutions produced by desiccation of sols. (See E. S. Hedges, *Chem. and Ind.*, 1932, **51,** 25.)

PECTOSE—The pulpy part of fleshy unripe fruits, insoluble in water, and which becomes converted into pectin (which is soluble) by the agency of heat or by the ripening process. It is this last-named sub-

PECTOSE (*Continued*)—
stance that imparts to their juices the property of gelatinizing (pectization) when boiled. Pectose is not of invariable composition, but has to be viewed as a compound of methoxylated pectin in which from 1 to 8 of the methoxy groups may be replaced by cellulose residues. (See Pectins.)

PEDOLOGY—The science of the soil.

PEGMATITE—See "Pegmatite Minerals of Poland, Maine," by Berman and Gonyer (*B.C.A.*, 1931, A, 818), and Clays (p. 198).

PELARGONIC ACID ($C_9H_{18}O_2$)—A product of the oxidation of oleic acid, and contained naturally in the volatile oil of *Pelargonium roseum,* N.O. Geraniaceæ, a native of the Cape of Good Hope and some other parts of South Africa. (See Geranium Oil.)

PELARGONIUM—A genus of plants, N.O. Geraniaceæ, including the ordinary geraniums.

"PELIGOT BLUE"—Hydrated copper oxide, used as a pigment.

PENAK RESIN (Chengal Resin, Malayan Dammar Penak)—The product of *Balanocarpus Heimii*, occurring in the Malay Peninsula, and called by the natives "chengal," or "penak." There are a number of grades based on colour varying from pale to amber. It melts at 90° to 92° C.; acid value, 38·9 to 45·4; is partially soluble in alcohol, ether, and petroleum, and wholly so in turpentine, and can be used for varnish-making. There are varieties known as "batu," "senggi," "hotan," "saraya," "daging," and "kepong" of differing characters.

PENCILS—See Inks.

PENETROMETER—A penetrating apparatus used for testing asphalt, greases, etc. (See *Ind. Chem.,* 1931, vii., 381.)

PENNYROYAL OIL is distilled (0·1 to 0·2 per cent.) from the leaves and tops of the herb *Mentha pulegium*, a native of England and other parts of Europe. It is a pale yellowish, limpid, essential oil of mint-like odour, containing, in association with piperitone, a ketonic substance named pulegone ($C_{10}H_{16}O$), of which it contains from 75 to 94 per cent.; sp. gr. is 0·93 to 0·96 at 15° C., opt. rot. $+13°$ to $+35°$ at 20° C., b.p. 99° / 14 mm., and ref. ind. 1·475 to 1·486 at 20° C. It is produced in Spain, Southern France, and Africa, and is used in medicine and as an insectifuge.

According to a recent determination, steam distillation of 100 kg. of this oil yielded 350 to 500 g. of a dirty straw-coloured oil, having *d* 0·8400 at 15·26° to 30° and acid value 0·31, containing 0·85 per cent. esters and 62 per cent. pulegone and piperitone. The oil is soluble in two parts of 70 per cent. alcohol.

"PENTACETATE"—A solvent composed of amyl alcohol with amyl acetate, for use in making cellulose lacquers.

PENTACHLORETHANE—See Solvents.

PENTADS—See Valencies.

"PENTALINE"—See Solvents.

PENTANE—See Hydrocarbons, p. 454.

"PENTASOL"—A solvent mixture of amyl alcohols made from the pentane of natural gas, for use in making cellulose lacquers; b.p. 116° to 136° C.

PENTAVALENT (Penta)—See Valencies.

PENTENE ("Pental")—See Amylene.

"PENTHRINIT"—New German patented explosive for universal use, consisting of a mixture of 10 to 70 per cent. penta-erythrit-tetranitrate ("Penthrit") and 90 to 30 per cent. nitroglycerine.

PENTLANDITE—A mineral double sulphide of iron and nickel, occurring in Norway and Argyllshire, containing 14 to 20 per cent. nickel.

PENTOSANS (hemicelluloses)—Substances which, upon hydrolysis, yield pentoses. By a process of acid hydrolysis under pressure the pentosans of cellulosic materials can be converted into fermentable sugars. As to their formulæ see G. Schorsch (*B.C.A.*, 1927, A, 1056), and with respect to their conversion into furfurol see Kullgren and Tydén (*B.C.A.*, 1929, A, 1278). (See Pentoses.)

PENTOSES—Carbohydrates of the saccharose class containing 5 carbon atoms, 3 of which are asymmetric, and they can therefore exist in 8 isomeric forms. The substances known as l',-arabinose ($C_5H_6O(OH)_4$) and l',-xylose are members of this series, and yield furfurol when boiled (hydrolysed) with strong hydrochloric acid. They occur as penta-polyoses or pentosans in many organisms, such as straw, wood, maize husks, etc.; these pentosans being related to the pentoses in the same way as starch and inulin are to the hexoses. They are extracted from plants or cotton by treatment with dilute solutions of the alkalies, and are converted into pentoses by hydrolysis with, for instance, dilute hydrochloric acid. Thus xylan, the pentosan contained in jute, bran, maize husks, and straw, yields xylose (wood-sugar) upon hydrolysis with dilute sulphuric acid. Although they cannot be fermented into alcohol by ordinary yeast, they can be made to yield a liquid fuel of alcoholic nature by means of certain bacteria. (See Cellulose, Carbohydrates, and Xylan.)

PENTOXIDES—Oxides containing 5 atoms of oxygen in the molecule—for example, phosphorus pentoxide (P_2O_5).

PEPPER—See Piperine and Piperidine.

PEPPER OIL—Extracted from common black pepper (*Piper nigrum*, N.O. Piperaceæ, a native of the E. Indies) by solvents (2·2 per cent.). It is yellowish, volatile, soluble in alcohol and ether, and contains phellandrene, cadinene, and dipentene. Its sp. gr. varies from 0·87 to 0·91, and its optical rotation from $-5°$ to $+12°$.

PEPPERMINT (OIL OF)—The essential oil obtained (0·3 per cent.) by distilling the leaves and tops of the *Mentha piperita* (N.O. Labiatæ). It contains from 45 to 90 per cent. of menthol ($C_{10}H_{20}O$), which deposits upon cooling. There are several varieties, including English, Italian,

PEPPERMINT (OIL OF) (*Continued*)—

American, Chinese, and Japanese, and a small production in Western Australia. The English and American oils contain from 40 to 69 per cent. menthol, together with some menthone and limonene, have a sp. gr. of from 0·90 to 0·91 at 15° C., opt. rot. $-25°$ to $-29·5°$, and ref. ind. 1·459 to 1·464 at 20° C.

The Esthonian oil has a sap. v. 0·808, ester number 10·384, and acetyl number 180·41; contains total menthol 50·21 per cent., and menthone 17·21 per cent. The dry plant contains up to 0·5 per cent. oil.

The Chinese oil contains about 70·57 free menthol, is light brown in colour, of rather disagreeable odour, bitter taste, and sp. gr. is 0·909.

The genuine "Japanese mint oil," derived from *Mentha arvensis*, has been variously described as consisting, on the one hand, mainly of pulegone, and, on the other hand, as containing from 73 to 83 per cent. free menthol, and has a lower sp. gr. and ref. ind. than the *M. piperita* oils. The wild Japanese mint oil is stated to consist mainly of ketones containing about 20 per cent. pulegone, 40 per cent. of *l*-menthone, 30 per cent. of *l*-limonene, and 5·8 per cent. fatty acids. (See Shinosaki and Nagasawa (*B.C.A.*, 1930, B, 264) and T. Cocking (*Analyst*, 1931, **56**, 702).)

It is also stated that the Sambi crop of Japanese peppermint oil produces about 50 per cent., and the Hokkaido crop about 38 per cent. menthol crystals.

The ordinary commercial Japanese oil is more or less dementholized before being placed on the market.

They are all used in perfumery, for flavouring, and in medicine, but the American oil, which constitutes about half of the world's supply, is the best adapted for perfumery.

See H. A. Braun (*B.C.A.*, 1930, A, 966) on the non-volatile constituents of *Mentha piperita*; Duncan and Short on the terpenes of the oil (*J.S.C.I.*, 1931, **50**, 198 T); and Spearmint Oil.

PEPSIN—The digestive (protein) ferment of gastric juice, which is active only in a dilute acid environment, hydrochloric acid of from 0·08 to 0·2 per cent. strength being more favourable than lactic or acetic acid, while neutralization suspends its action. It is secreted in certain glands of the stomach, and by its agency albuminoids, etc., partaken as foods are rendered assimilable as peptones.

The "pepsin" preparation of commerce comes chiefly from the United States, and is obtained from the glandular layer of pigs', sheep's, or calves' stomachs. Pepsin is a nearly white amorphous substance, insoluble in alcohol, but very soluble in dilute acids and glycerine. Its solutions are coagulated by boiling, and it then loses its digestive power. It is sometimes used as a substitute for rennet. (See Enzymes, Gastric Juice, and Zymogens.)

PEPTIZATION—See Colloid Chemistry, p. 227.

PEPTONES—Products of the hydrolysis of proteins; also result from the action of dilute acids or enzyme action of pepsin in the juices of the stomach upon the albuminous content of food. They are soluble in

PEPTONES (*Continued*)—

water, diffuse readily through vegetable parchment, are not precipitable by ammonium sulphate, and are not coagulated upon heating, so that they are in the best state for assimilation in the human economy. (See Bernhardi and Tartarini, *B.C.A.*, 1927, A, 582.)

PER—A prefix used in respect of compounds in which some element is above that of lower compounds of the same class or exhibits an unusually high valence; thus we have barium oxide (BaO) and barium *per*oxide (BaO_2), and, again, potassium chlorate ($KClO_3$) and *per*chlorate ($KClO_4$).

"PERACTIVIN" (**"PERAKTIVIN"**)—A white powder made by mixing toluene-sulphon-dichloramide with enough anhydrous sodium carbonate to remove the unpleasant odour, and from it bleaching solutions are prepared by dissolving in 10 per cent. sodium carbonate or 3 to 5 per cent. sodium hydroxide solution. The bleaching is attributed to the liberation of oxygen. (See R. Fiebelmann, *B.C.A.*, 1931, B, 390; and Aktivin.)

PERBORATE OF SODIUM—See Sodium Compounds.

PERBORIN—Perborate of sodium.

PERCARBONATES—See Carbon Oxides, p. 147.

PERCHLORATES—See Chlorine Compounds (p. 186).

PERCHLOROETHANE (C_2Cl_6)—Crystallizes in rhombic plates of camphor-like odour; m.p. 185° C. (See Carbon Trichloride.)

PERCHLORETHYLENE—See Carbon Dichloride and Solvents.

PERCOLATION—Filtering or passing through, as when making drinking coffee the dry coffee is percolated and the soluble parts extracted by hot water.

Apparatus for continuous percolation and other applications has been described by B. S. Evans (*Analyst*, 1926, **51**, 229); see also *Ind. Chem.*, 1926, ii., 282.

PERFUMES—Preparations of a volatile nature consisting for the most part of pleasant, odoriferous substances dissolved in alcohol. Some of the better-known essences are obtained by distilling the flowers or flower-petals of plants with water—attar of roses, for example—while others are extracted therefrom by means of solvents such as light petroleum spirit or alcohol, the solvent being afterwards evaporated by distillation in a vacuum. Yet others, such as the tuberose and jonquil (the delicacy of which may be impaired by the distillation process or solvent action) are obtained by "enfleurage"—a method which consists in pressing the flowers against a layer of cold fat (such as lard) or petroleum jelly spread over glass plates; or by drawing warm, moist air through the flowers and passing the current charged with the odoriferous principles over fatty layers, from which the perfume is subsequently extracted by strong alcohol. The subsequent evaporation of the alcohol yields the "quintessences" as residual products.

PERFUMES (*Continued*)—

More recently, carbon dioxide gas, as generated from the liquefied form, has been patented for the extraction of oils and essences from plants such as cloves, caraway seeds, and iris root.

The production of perfumes by the hybridization of scentless flowers has been suggested, but little has been done in that direction so far.

The odorous constituents of the apple include the amyl esters of formic, acetic, caproic, and caprylic acids, together with acetaldehyde and a small amount of geraniol. A synthetic mixture of apple oil is now made.

Ethyl butyrate is the odoriferous constituent of the pineapple, and the pear owes its fragrance to amyl acetate. Coumarin, to which the Tonquin bean owes its fragrance, is now made artificially; so also vanillin, which gives its pleasant odour to the vanilla pod, is now largely made from eugenol (the chief constituent of oil of cloves).

Many butyrates occur frequently in nature, and are synthetically prepared with a view to their use in preparing perfumes; benzyl butyrate enters into the composition of artificial jasmin perfume; geranyl butyrate, having an odour like that of the rose, is contained in good geranium oils; phenyl butyrate is used as a base of artificial preparations of rose; while rhodinal butyrate has a pleasant fragrance, and is employed in making "moss rose" compositions.

Geraniol ($C_{10}H_{18}O$), which is largely used in perfumery, can be prepared by polymerizing citronella oil, and subsequent fractional distillation. (See Geraniol and Citronella Oil.)

Heliotropin is referred to under that heading.

Hawthorn ("may blossom," aubépine) is reproduced by use of anisic aldehyde prepared by oxidation of aniseed oil.

Modern lavender, as artificially prepared, consists of about 40 per cent. *l*-linalyl acetate, admixed with camphor, menthol, borneol, etc.

Musk is referred to under that heading.

An artificial essence of violets named ionone ($C_{13}H_{20}O$) is made from citral (to which the odour of lemons and lemon grass is due), and there are many synthetically prepared perfumes, as distinct from those derived from flowers, or made in imitation of natural products, as, for example, heliotropin, sold as "white heliotrope." So again, a ketonic substance named irone is a fragrant oil made from the root of iris (orris), having the odour of the violet, which it acquires upon exposure to the hot rays of the sun, the freshly dug root having but a feeble perfume.

Among the new synthetic perfumes may be mentioned "fragasol," which is the butyl ether of beta-naphthol, analogous to yara-yara and neroline, which are the methyl and ethyl ethers respectively.

"Benzilisoeugenol" has a fine carnation odour, and "rhodinol," or rose-aldehyde, is probably a mixture of aldehydes used in the manufacture of artificial attar of roses.

The aromatic aldehydes are largely used in the production and blending of perfumes, the more important ones being anisaldehyde, benzal-

PERFUMES (*Continued*)—

dehyde, cuminaldehyde, salicylaldehyde, and phenylacetaldehyde (hyacinthin). (See J. McLang, *C.T.J.*, 1926, **79,** 190, 307, 359, 441.)

Stysolyl acetate has the perfume of the calyx of the rose, and amyl benzyloxide, which has a marked gardenia odour, is used for perfuming soaps, a trace of methyl para-cresol improving it.

Some of the essential oils constituting the bases of perfumes are obtained by pressure of the fruit rinds containing them, as, for example, the orange, lemon, and bergamot oils; and many others such as eucalyptus oil, camphor oil, and the terpenes are commercially available in large quantities, and used either alone or in combination with other extractives in compounding various perfumes.

Methyl anthranilate, traded as neroli oil, is a colourless, crystalline perfume made by heating anthranilic acid and methyl alcohol together with sulphuric acid, followed by distillation; while methyl benzoate (made similarly, using benzoic acid in place of anthranilic acid) is put up as "Essence Niobe."

In the perfume industry, phenylethyl alcohol ($C_6H_5.CH_2.CH_2OH$) of rose-like sweetness is produced by the reduction of phenyl acetic ether by metallic sodium, the functional ester group CO_2R being converted into the alcoholic radical CH_2OH.

The use of isopropyl alcohol ($CH_3.CH(OH).CH_3$) (b.p. 82·8° C., and sp. gr. 0·789) has been advocated for use as a solvent and diluent in making perfumes, and its slight odour can be easily "touched up" by the use of certain esters.

Many chemical esters are used in perfumery, and, apart from the essential oils used in making perfumes and soaps, large quantities of these are used in compounding such drinks as lemonade and sundry alcoholic liqueurs, and for flavouring purposes, also in cooking, confectionery, and medicine, so that the trade in these oils, and the perfumes made from them, is one of large dimensions and importance.

An instrument termed the "evapolactometer," devised for testing perfumes, is based upon a means of volatilizing them, so that the sense of smell renders their identification much easier. It consists of a thermometer, the mercury reservoir of which is surmounted by an electrical resistance and a very finely polished, silver-sheathed rod. Some of the perfume to be tested is poured on this rod, and electricity is passed through the resistance, in which way the temperature is slowly raised, when the odorous constituents of the perfume evaporate according to their individual degrees of volatility.

References: "The Manufacture of Synthetic Perfumes and Flavours," by P. May (*Ind. Chem.*, 1927, iii., 158); Parry's *Cyclopædia of Perfumery* (J. and A. Churchill, London, 1925); W. A. Poucher's *Perfumes, Cosmetics, and Soaps*, 3rd edition (Chapman and Hall, London); Balsams, Benzyl Benzoate, Essential Oils, Ionone, Jasmine Oil, Odour Theory, Stearoptenes, and Terpineol.

"PERHYDROL"—A name given to concentrated peroxide of hydrogen (100 volume strength).

PERICLASE (MgO)—Crystal system, No. 1, and sp. gr. 3·67. (See Magnesium.)

PERIDOTE (Mg_2SiO_4)—See Chrysotile and Silicon.

PERIDOTITES—Name of igneous rocks of olivine character.

PERILLA OIL—There are several varieties of this essential oil, including that derived from the seeds of *Perilla ocimoides* (habitat, North India, China, and Japan), and made chiefly in Manchuria. The yield from the dried seeds is from 38 to 49 per cent., the oil being of a greenish-yellow or brownish colour; sp. gr. 0·932 to 0·945 at 15·5° C., sap. v. about 189 to 197, i.v. 176 to 193, and ref. ind. 1·4825 at 15° C. It is soluble in alcohol and ether, and used as a substitute for linseed oil in making printing inks and varnishes, and to some extent as an edible oil in Japan and China.

The polymerized oil is viscous at 304° C. and the iodine value decreases rapidly. (See M. Toch, *B.C.A.*, 1927, **46**, B, 49.) The fatty acid constituents include palmitic, oleic, linoleic, and linolenic acids.

Somewhat different characteristics are given in a recent paper by H. P. Kaufman, who does not mention palmitic acid as a constituent (*B.C.A.*, 1931, B, 31).

The oil from *P. nankinensis* is stated to result from the decomposition of a glucoside in the leaves, and to contain 20 to 30 per cent. limonene, 44 to 57 per cent. perillaldehyde ($C_9H_{13}.CHO$), and some pinene. A substance designated the *syn-oxime* of perillaldehyde, prepared from this oil, is stated to be 2,000 times as sweet as sugar.

The dried leaves of *P. citriodora* are said to yield 2 to 3 per cent. oil of sp. gr. 0·911 to 0·913, containing 60 per cent. citral, and the seed-cake is used as a fertilizer in Japan.

PERIODIC ACID—See Iodine Compounds.

PERIODIC LAW—See Periodic Law, p. 302.

"PERMAC"—A jointing material or cement, stated to be chemically neutral and not subject to oxidation, adhering firmly to glass, and used for making metal-to-metal joints capable of withstanding pressure.

"PERMALLOY"—A nickel-iron alloy of high electrical permeability containing about 78·5 per cent. Ni; specially good for submarine telegraphy and stated to transmit four times more rapidly than ordinary cables. (See E. M. Doloraine, *J.C.S. Abs.*, 1925, I., p. 639; *Ind. Chem.*, 1926, ii., 13; and *B.C.A.*, 1930, B, 616.)

PERMANENT WHITE—See Barium (Sulphate).

PERMANGANATES—See Manganese Compounds, p. 561.

PERMEABILITY—See Hydrogen, Occlusion, and Porosity.

"PERMUTIT"—A number of preparations, called "permutits," are artificially produced silicates (zeolites), capable of exchanging their basic constituents when placed in certain solutions; so that when employed for softening water an exchange takes place, the soda of the "permutit" passing into the water and being replaced by the lime and magnesia (the hardening constituents) of the water.

"PERMUTIT" (*Continued*)—

The general method of preparation consists in melting china clay (kaolin) with quartz and sodium carbonate, and washing with water, the product being a double silicate of soda and alumina, containing about 46 per cent. of SiO_2, 22 per cent. of Al_2O_3, 13·6 per cent. Na_2O_2, and 18·4 per cent. H_2O. The permutit is revivified by passing a fairly strong solution of common salt through it, which restores it to its original constitution, so that after washing it with water, it can be used again for softening further quantities of hard water.

This base-exchange process has been represented as utilising the reaction:

$$Na_2O,Al_2O_3, \times SiO_2,yH_2O + CaCl_2 \Longleftrightarrow CaO,Al_2O_3, \times SiO_2yH_2O + 2NaCl.$$

The reactions are purely of mass character, and may be also generally represented by the following illustrative equations, Z standing for the zeolite:

$$Na_2O(Z) + CaSO_4 \Longleftrightarrow CaO(Z) + Na_2SO_4,$$

and

$$CaO(Z) + 2NaCl \Longleftrightarrow Na_2O(Z) + CaCl_2.$$

In practical use the zeolite is contained in suitable tubes or other containers, through which the water to be softened is passed.

The zeolite process is inefficient in the presence of acid or mud, which must be first of all removed before softening.

According to E. F. Armstrong, a "gel" containing about 50 per cent. water which is very active in exchanging its sodium for calcium and magnesium can be obtained by mixing concentrated solutions of sodium silicate and sodium aluminate, and exposure of the set jelly to the air. This material, named "Doucil," is believed to be represented by the formula $Al_2O_3.Na_2O.5SiO_2$.

Two natural zeolites are known in the United States as *boronite* and *refinite*. (See "Doucil," Water Softening, and *Ind. Chem.*, 1929, v., 434.)

PERNAMBUCO (Lima or Nicaragua Wood)—A red wood from *Cæsalpinia echinata*, which yields a red dye extract. There are various species of Cæsalpinia, all of which yield red dye woods. (See Brazil Wood Dyes.)

PEROXIDE OF HYDROGEN—See Hydrogen Dioxide.

PEROXIDE OF SODIUM—See Sodium Compounds.

PEROXIDES—This term indicates oxides of higher degree than the ordinary oxides; for example, barium oxide (BaO) is the ordinary barium oxide, whereas the peroxide (dioxide) is BaO_2.

There are some organic peroxides, among which may be mentioned acetyl peroxide, $(C_2H_3O)_2O_2$ (an explosive liquid body prepared from acetic anhydride by the action of barium dioxide); ethyl hydrogen peroxide, $C_2H_5.O.O.H$; diethyl peroxide, $C_2H_5.O.O.C_2H_5$; and acetone peroxide, $(C_3H_6O_2)_2$. These liquids are more or less unstable, and are

PEROXIDES (*Continued*)—
made by the agency of hydrogen peroxide in presence of potassium hydroxide. According to Mondain-Mouval and Quanquin, the oxidation of certain hydrocarbons (pentane, hexane, octane, petrol) by air at 300° or somewhat lower gives an oily liquid with marked oxidizing properties, which evolves hydrogen and gives sodium formate and methyl alcohol when treated with sodium hydroxide, and they conclude that this oily substance is a mixture of peroxides (*B.C.A.*, 1930, A, 1157). (See Ozonides, "Sanitas" Oil, and Turpentine.)

PERRY—Fermented juice of pears.

PERSIAN BARK—See Cascara Sagrada.

PERSIAN BERRIES (Frangula; Buckthorn)—The dried bark of *Rhamnus frangula*; habitat, Europe, Siberia, etc.; containing a glucoside yielding a yellow dye (named rhamnetin) and rhamnose. (See Rhamnicoside, p. 441.)

PERSIAN RED—Lead chromate.

"PERSIL"—A proprietary soap washing powder containing an oxygen bleaching agent (sodium perborate, 9·8 per cent.).

PERSIMMON (**Diospyroskaki**)—A genus of Ebenaceæ, which furnishes a good timber, is a native of Japan and grows abundantly in Eastern Chekiang and in some parts of Western China. The Chinese prepare a lacquer from the fruit, the product being chiefly used as a waterproofing material for covering paper umbrellas and other articles. It is packed in "catties"—a catti = 1⅓ lbs. A sweetmeat known as "Figues-caques" is said to be made from the fruit in France (see *C.T.J.*, 1930, **87**, 412, and *Chambers' Encyclopædia*, 1901, "Date Plum," p. 692).

PERSOZ'S REAGENT—A mixture which at 45° C. will dissolve silk, but not wool; made by dissolving 10 grammes zinc chloride in 10 c.c. water, and shaking up with 2 grammes of zinc oxide.

PERSULPHATES—The persulphates of potassium, sodium, and ammonium, corresponding to persulphuric acid ($H_2S_2O_8$), are crystalline compounds which can be prepared by electrolysis of their sulphates or bisulphates. They are valuable oxidizing and bleaching agents, and if kept dry and in the dark can be stored unaltered for long periods, but in ordinary aqueous solutions they decompose, and more rapidly as the temperature increases. This tendency to decomposition is restrained to some extent by the addition of sodium sulphate. The sodium compound ($Na_2S_2O_8$) is the most effective, and is used in one method of preparing hydrogen dioxide. (See Hydrogen Dioxide, and Sulphur Compounds (Sulphates), p. 880.)

PERU BALSAM—See Balsams.

PERUVIAN BARK—See Cinchona.

PERYLENE—A hydrocarbon ($C_{20}H_{12}$), m.p. 264° C., yellowish in colour, can be prepared from beta-di-naphthol, which in turn is made by adding beta-naphthol to a hot dilute solution of ferric chloride.

PERYLENE (*Continued*)—

Numerous derivates used as vat dyestuffs are prepared from it. (See *C.T.J.*, 1925, **77**, 741, and F. A. Mason (*Ind. Chem.*, 1929, v., 111 and 137).)

PETALITE ($30SiO_2,4Al_2O_3,Na_2O,2Li_2O$)—A native silicate of aluminium and lithium of crystal system, No. 5, and sp. gr. 2·5.

PETIT-GRAIN OIL—Distilled from the leaves and unripe fruit of the lemon tree (*Citrus bigaradia*). It resembles neroli oil in odour, is yellowish in colour, soluble in alcohol and ether, has a sp. gr. of from 0·867 to 0·895, acid value 0·7 to 0·97, and is used in perfumery. The Paraguay oil is best known, but that from Tanganyika has recently been reported as equally good. (See Glichitch and Naves (*B.C.A.*, 1930, B, 37 and 740) and *B.C.A.*, 1931, B, 45.)

PETROL—See Motor Spirit.

PETROLATUM—Petroleum jelly.

PETROLEUM (**Rock or Mineral Oil**) occurs in the Miocene rocks of tropical and subtropical countries, and in smaller quantities in older rocks of colder countries. It is a natural, dark-coloured, oil-like deposit of hydrocarbon character, found mainly in rock formations of either the Tertiary or Carboniferous periods; sometimes occurring in beds or lakes as in Trinidad, and at other times flowing from clefts of rocks or from deep wells, as in the northern parts of the United States, particularly between Pittsburg and Lake Erie. Deposits also occur in parts of Canada (the production in that country amounting to 339,000 barrels in 1926), Germany, Poland, Persia, Roumania, Galicia, Burma, Sarawak, Java, East Borneo, Assam, the Crimea, and small ones at Hardstoft in Derbyshire, also in Dorsetshire, Norfolk, and Nottinghamshire; the Derbyshire well, however, yields less than a ton per day.

The Scottish shale industry continues, but the total output from all domestic services is not more than 170,000 tons per annum. Most of our oil comes from Burma, but Trinidad and Barbados yield supplies, and Mesopotamia holds out good promise.

The total output of petroleum in 1920 was over 97,000,000 tons (of which the British Empire controlled only 4 per cent.); in 1928, 1,322,896,000 barrels; while the U.S.A. produced 898,011,000 barrels in 1930.

The figures for output of the crude oil in 1931 and 1932 are given in the *C.T.J.*, 1932, **90**, 207.

The petroleum from all fields consists in the main of hydrocarbons, associated with small proportions of asphalt and compounds containing oxygen, nitrogen, and sulphur, and are worked on a large scale as the source of a number of valuable products. The crude oil can be purified to some extent by percolation through fuller's earth or specially prepared powdered bauxite, and there are various processes for desulphurizing petroleum, the "Frasch" process consisting of distilling the oil over copper oxide, although for certain reasons this process is not suitable for the treatment of the crude Mexican oil. Sodium hypochlorite

PETROLEUM (*Continued*)—

is another convenient purifying material for this purpose, and sodium plumbite is also used for the "sweetening" of petroleum, owing to its power of removing sulphur compounds such as hydrogen sulphide, and most mineral oils can be rendered colourless by the more or less prolonged action of sulphuric acid.

The hydrocarbons of many of the natural petroleums are of the same series, although contained in varying proportions; but while the American oils consist in the main of paraffin hydrocarbons, the Russian oil contains up to 80 per cent. of the general formula C_nH_{2n}, known as naphthenes, such as cyclopentane (C_5H_{10}) and cyclohexane (C_6H_{12}), which are isomeric with the olefines.

The Burma oil contains from 10 to 20 per cent. of aromatic hydrocarbons, including benzene and toluene; these can be separated from the aliphatic portion by sulphonation and distillation with superheated steam, and the residues used for burning and illuminating purposes. When distilled (without cracking) it gives (according to W. J. Wilson):

Gasoline (to 160° C.)	28
Kerosene (160° to 300° C.)	35
Intermediate oil	6
Paraffin, m.p. 136° F.	5
,, m.p. 125° F.	3
,, soft (sweats)	2
Lubricating oil base	13
Residuum	8
	100

Wax from Burma crude oil is stated to furnish a complete range of paraffins from $C_{21}H_{44}$ to $C_{34}H_{70}$.

The oil produced at Hardstoft, in this country, contains naphthenes, and an early sample furnished upon examination 7 per cent. motor spirit, 40 per cent. burning oil, 20 per cent. gas oil, 30 per cent. lubricating oil, and 3 per cent. solid paraffin.

That portion of Peruvian petroleum boiling between 150° and 350° C. is stated to contain some hydrocarbons having a pronounced odour of turpentine.

Crude petroleum is used to some extent as a substitute for coal in locomotives, has a sp. gr. ranging from 0·78 to 0·97 or more, and by fractional distillation yields a number of products, including the so-called petroleum ether, benzine, gasoline, kerosene, paraffin oil, heavy lubricating oils, petroleum jelly, paraffin wax, coke, and asphalt, which are described under their respective names. The various fractional distillates are further separated and refined by redistillation.

Crude petroleum is roughly classified as (1) paraffin base, (2) asphalt base, (3) mixed base, according to the predominating character of the oil.

Of late years the distillation of mineral oils has been chiefly effected by high vacuum methods, and although this is always accompanied by

PETROLEUM (*Continued*)—

partial decomposition, it does not seriously affect the distillation so long as 300° to 320° C. temperature is not exceeded. Many types of plant, including the Schultze and Steinscheider plants, have been designed to avoid cracking, working under an absolute pressure of about 2 m.m. without steam or at about 20 m.m. pressure with steam injection into the oil. High vacuum distillation is particularly valuable in respect of the heavy inferior asphaltic oils. (See *C.T.J.*, 1925, **77,** 565, and D. Stewart, *Chem. and Ind.*, 1929, **48,** 1157.)

The flash-points fixed for fuel oil by the British authorities are as follows: Lloyd's Register of Shipping, 150° F.; London County Council, 150° F.; and the Admiralty, 175° C. (See Flash-Point, p. 356.)

Mexican fuel oil is reputed to have a sp. gr. of about 0·95 at 15·5° C., flash-point (open) over 65·5° C., and calorific value about 18·750 B.Th.U.s per lb.

The spontaneous ignition temperatures of various fuel oils in an atmosphere of oxygen have been determined as follows: Petrol, 270° and 279° C.; kerosene, 251° to 253° C.; gas oil, 254° C.; residual oils, 259·5° to 269° C.; commercial benzol, 566° C.; commercial toluol, 516° C.; gasworks tar creosote, 415° to 473° C.; creosote from low-temperature tars, 290° to 350° C.; shale oil, 251° C.; whale oil, 273° C.

The benzene produced from many crude petroleums requires no chemical treatment, and is largely used as motor spirit; but the "white spirit" and "kerosene" which follow (and are used in lamps) are refined by filtration through powdered bauxite or fuller's earth, which removes the sulphur compounds and can be regenerated for renewed use by heating.

Paraffin wax is separated from the higher distillate portion containing it, by cooling to 7° C., and squeezing out the heavy associated oil, which is utilized as lubricating oil after redistillation. Both paraffin and kerosene can be obtained white by filtration through bauxite.

Coke or pitch is finally left in the retort, and, the former being very pure, finds a ready sale to the manufacturers of electric-light carbons and carbon crucibles, whilst the pitch can be used either as fuel or can be oxidized or sulphurized, and thus utilized in making artificial asphalt.

Serious decomposition of petroleums does not occur below 300° to 320° C., but when "cracked" at about 700° to 750° C., most of them yield a distillate containing toluol, and large quantities of that material were thus obtained during the Great War. Light oils from the petroleum "cracking" process contain benzene and toluene, but no naphthalene.

By the cracking of the high-boiling distillates from crude petroleum —viz., those boiling at 225° C. and upwards—low-boiling fractions belonging mostly to the aliphatic or paraffin series of suitable character for use in internal combustion engines are obtained. This is carried out by subjecting them to a high temperature and pressure in a pipe-still, and then passing into a reactor, where the "cracking" takes place, the light oils being separated from the heavy residues in a rectifying column, a residue of coke being left in the "reactor." Cracking of petroleum can also be carried out in the vapour phase, and in some

PETROLEUM (*Continued*)—

processes various agents are used as catalysts. It is reported that the operation in respect of gasoline can be controlled to give maximum yields of the hydrocarbons of any series—paraffin, naphthenes, olefines, diolefines, acetylenes, and aromatics—or even to give a large yield of a single hydrocarbon.

The "cracking" for conversion of the higher fractions of petroleum into motor spirit produces large quantities of permanent gas containing from 10 to 60 per cent. of olefine gases, including ethylene, propylene, and the butylenes, constituting an important crude material for the manufacture of secondary and tertiary alcohols, etc. (See report of paper by H. M. Stanley, *Chem. and Ind.*, 1929, **48,** 1204, and one by E. N. Gougeon (*Chem. and Ind.*, 1931, **50,** 320) on "High Pressure in Chemical Industry," in which the cracking process, the hydrogenation of the heavier and inferior petroleum oils, and the developments in the natural gas industry are dealt with; *C.T.J.*, 1926, **79,** 680; *Chem. and Ind.*, 1928, **47,** 988; R. H. Griffith on "The Valuation and Cracking of Gas Oils" (*J.S.C.I.*, 1929, **48,** 252 T); H. A. Wilson on "Theory of Cracking Petroleum" (Proc. Roy. Soc., 1929, A, **124,** 16-45); and Cracking.)

Fatty acids can, it is stated, be obtained from petroleum hydrocarbons by catalytic oxidation, using air or oxygen in association with certain lead or mercury compounds (which apparently dissolve in the products of the process) at a temperature of 115° to 120° C., and under a pressure of three atmospheres, with agitation in the presence of water for some seven hours. The oxidation products have been stated at from 7 to 20 per cent. water, 25 to 40 per cent. lower fatty acids, with small amounts of aliphatic aldehydes and ketones, from 50 to 78 per cent. of higher fatty acids, and 10 to 15 per cent. of unsaponifiable matters. The products are fractionated by distillation, and the higher fatty acids thus obtained mixed with 10 to 20 per cent. of tallow or cocoa-nut oil fatty acids can be used to make soap.

By another process—viz., passing the vapour of petroleum hydrocarbons and air through a series of catalytic agents (uranium and molybdenum oxides) at from 240° C. to something under 500° C.—oxidation of the aliphatic hydrocarbons occurs, and among the products are certain oxygenated acids of aldehydic character, which admit of saponification with calcium hydroxide and caustic soda. These acids are of a resin-like character, and the soaps, as also certain other associated products formed from them, have commercial value as lubricants, and frothing oil for use in the field of oil flotation. The practicability of these two processes is, however, stated to be doubtful, owing to the relative absence of straight chain hydrocarbons in petroleum oil and the doubtful character of the reputed fatty acids which are obtained.

Fatty acids can also be obtained by the chlorination of certain paraffin hydrocarbons at 160° C., subsequent elimination of the hydrogen chloride thus produced, and oxidation of the resulting olefine by means of potassium permanganate or ozone. These several products, however, are of vague character, and so far it has not been

PETROLEUM (*Continued*)—

possible to identify any normal fatty acid as a constituent (G. Collin, *J.S.C.I.*, 1930, **49**, 333 T).

American (U.S.A.) petroleum is said to yield on average the following fractions upon distillation: light naphtha 17, kerosene 50 to 54, lubricating oil 17, paraffin wax 2, and loss 10.

The International Union of Pure and Applied Chemistry in conference July, 1928, decided to adopt a classification for petroleum products as follows: Spirits (essences), upper limit of distillation 225° C.; lamp oils, lower limit for ignition 25° C.; and combustible residue, lower limit for ignition 50° C.

Origin of Petroleum—One supposition is that mineral oil and natural gas are formed in nature by the action of water on metallic carbides present in the heated interior of the earth; another that it is the product of volcanic action; but the balance of opinion is in favour of the view that they are derived from organic matters by chemical changes operating over long periods of time. As all petroleums contain so-called algæ wax, one hypothesis favours enormous masses of algæ accumulated over immense periods of time in marshy areas as its originating material. There is also a "resin" theory, and the further view that petroleum, like all the carbon deposits having a vegetable origin, is derived from cellulose, the composition of which shows that it can supply sufficient carbon and hydrogen to account for the quantities of these elements found in the liquid and gaseous hydrocarbons, although the changes which the cellulose in that case must have undergone are different from those which produce coal, lignite, or peat. The close similarity between the oils from the Balkash Sapropelite and the natural petroleum fractions has been viewed as giving experimental support to the organic origin hypothesis.

Artificial petroleum is produced by hydrogenating acetylene at high temperatures and pressures, and this has led to the suggestion that the natural petroleums have been formed by some such process.

Fischer (of Germany), in respect of his process for the synthesis of liquid fuel, has stated that it renders possible the production of any aliphatic petroleum product in the pure state, and that it is based in the main upon reduction of a mixture of carbon monoxide and hydrogen in presence of a catalyst (iron or cobalt) at a temperature below 300° C. (See "Synthol.")

The dry natural gas from petroleum wells rarely contains more than 0·5 gallons of gasoline per 1,000 cubic feet, and "casing-head" gas up to 10 to 15 gallons. Natural gas invariably accompanies petroleum in oil-sands, and is extracted by compression and absorption methods. The casing-head gas consists of a mixture of the lower members of the paraffin series, including methane, ethane, propane, butane, pentane, etc., and can be used in some cases for heating purposes by combustion. The absorption method consists in scrubbing the gas with a suitable solvent oil.

Further references: Dunstan and Pitkethly (*J. Inst. Petrol. Tech.*,

PETROLEUM (*Continued*)—

1924, x., 728-757); description of a petroleum refinery in Scotland (*Ind. Chem.*, 1925, i., 21); Leslie and Potthoff (*B.C.A.*, 1926, B, 811); Gordon and Merry (*J.S.C.I.*, 1927, **46,** 429 T); the chemical reactions involved in the refining of petroleum are described by Birch and Norris (*Ind. Chem.*, 1928, iv., 423); B. T. Brooks on "The Industry in U.S.A." (*J.S.C.I.*, 1928, **47,** 225 T); A. E. Dunstan on "Petroleum as a Source of Synthetic Material" (*Chem. and Ind.*, 1929, **48,** 139); A. E. Dunstan (*J.S.C.I.*, 1930, **49,** 310 T); *Chem. and Ind.*, 1931, **50,** 557); "Constituents of Petroleum," by J. von Braun (with others) (*B.C.A.*, 1931, A, 1396); J. E. Hackford (*Chem. Age,* 1932, xxvi., 73); *A Treatise on Petroleum,* by Boverton Redwood (5th edit.) (Griffin and Son, London); *Handbook of the Petroleum Industry,* by D. T. Day (John Wiley and Sons, N.Y.); *The Examination of Petroleum,* by Hamar and Padgett (McGraw-Hill Book Co., N.Y.); *Low-Temperature Distillation,* by North and Garbe (Sir Isaac Pitman and Sons); *The Chemistry of Petroleum and its Substitutes,* by C. K. Tinkler (Crosby Lockwood and Co.); *The Petroleum and Allied Industries,* by J. Kewley (Baillière, Tindall and Cox); and *Petroleum Technology,* by L. Gurwitch, translated by H. Moore (Chapman and Hall). (See also Asphaltenes, Benzene, Shale, and Torbanite.)

PETROLEUM ETHER (**CANADOL, LIGROIN**)—The fractional distillate from petroleum, b.p. 40° to 70° C., and sp. gr. 0·635 to 0·660, purified by washing with sulphuric acid, then with soda, and subsequent redistillation. It contains a large proportion of the lower paraffin hydrocarbons (heptane, hexane, etc.), is very inflammable, and constitutes a volatile solvent.

PETROLEUM JELLY (**Petrolatum**) is an emulsion of soft paraffins (highly saturated hydrocarbons) dispersed in heavy oils, the viscosity of which increases gradually with decreasing temperature until the "gel" state is reached. There is no separation of crystalline wax, which is only obtained upon distillation of the jelly (in the distillate). It is a high-boiling distillation product made from the still residue left after the distillation of petroleum, decolourized by filtration in a heated state through fuller's earth or animal charcoal, and used as a lubricant, rust preventive, in making ointments, leather dressing, polishes, and as a perfume extractor in enfleurage. Its use in wire-rope making is described in the *C.T.J.*, 1928, **83,** 30. (See "Vaseline.")

PEWTER—See Alloys and Tin.

***p*H VALUES**—See *Colorimetric and Potentiometric Determination of pH,* by I. M. Kolthoff (Chapman and Hall, London); Hydrogen-ion Determination and Volumetric Analyses.

Ph—An abbreviated term sometimes used for phenyl (C_6H_5).

PHAGOCYTES—Amœboid cells, also called leucocytes (the white corpuscles of the blood), capable of ingesting or destroying bacteria and

PHAGOCYTES (*Continued*)—
viruses in the blood; this phagocytic activity is said to be increased by other substances known as Opsonins. (See Bacteria.)

PHARMACY—The preparation of medicinal agents, the British Pharmacopœia being the official list of substances employed. (See *The Extra Pharmacopœia,* by Martindale and Westcott, 19th edition (H. K. Lewis and Co., Ltd., London); *Pharmaceutical Formulas,* by Woolley and Forrester (C. and D., 42, Cannon Street, London); *Bioassays: A Handbook of Quantitative Pharmacy,* by J. C. Munch (Baillière, Tindall and Cox, London); *Remington's Practice,* by Cook and La Wall, 7th edition (Lippincott and Co., London); A. O. Bentley's *Textbook,* 2nd edition; *Gadd's Synopsis* of the B.P. (Baillière, Tindall and Cox, London); and Drugs.)

PHASE and PHASE RULE—See Colloid Chemistry.

PHELLANDRENE—A terpene ($C_{10}H_{16}$) constituent of certain eucalyptus oils; b.p. 171° C. (See Essential Oils, Eucalyptus Oils, and Terpenes.)

PHEN—A prefix indicative of phenol and benzene derivatives.

PHENACETINE (**Aceto-p-phenetidine**) ($C_{10}H_{13}O_2N$)—A colourless crystalline compound (aceto-phenetidine), soluble in water, alcohol, and ether; used as a remedy for neuralgia, headache, etc.; m.p. 135° C. Its manufacture from *p*-chloronitrobenzene as compared with other methods is described by D. H. Richardson (*J.S.C.I.*, 1926, **45,** 200 T).

PHENACITE ($GlSiO_4$)—Silicate of glucinum; crystal system, No. 3, and sp. gr. 7·5 to 8·0. (See Glucinum.)

PHENANTHRENE [$(C_6H_4CH)_2$]—A colourless crystalline substance isomeric with anthracene, which it accompanies in coal tar; soluble in alcohol, ether, benzol, etc.; m.p. 101° C., b.p. 332° C.; used in making black dyestuffs.

PHENAZONE—See Antipyrine.

PHENOLATES (**Phenates, Phenoxides**)—Compounds formed from phenols and metals by substitution of the hydroxyl hydrogen—for example, sodium phenolate or phenate (C_6H_5NaO), which is made by dissolving phenol (C_6H_5HO) in caustic soda solution.

PHENOL BLUE—See Indamines.

PHENOLOIDS—A name given to the phenolic and xylenolic principles of so-called "high-boiling acids" obtained in the redistillation of tar from blast furnaces and coke ovens. The exact constitution of these products is largely a matter of speculation, but they exhibit relatively high boiling-points as compared with the cresols, being found in the residue obtained after separation of the cresols by fractional distillation, and it is believed that they consist chiefly of xylenols or dimethylhydroxybenzenes. They exhibit greater bactericidal properties than the cresols, are less poisonous than phenol, and are used in making disinfectants, sheep dips, insecticides, larvicides, weed-killers, and cutting compounds for engineering purposes, as they form good emulsions in aqueous soap solutions. (See Phenols and Xylenols.)

PHENOLPHTHALEIN ($C_{20}H_{14}O_4$) (**Dihydroxy-diphenyl-phthalide**) or $(C_6H_4OH)_2.CO.C_6H_4CO$—A creamy-white powder used as a purgative, dye base, and indicator. A solution of ½ per cent. in equal parts of alcohol and water gives a strong pink colour when rendered alkaline; m.p. 250° C. (See Phthaleïns and Volumetric Analyses.)

PHENOL RESINS—See Gums and Resins.

PHENOLS—A series of bodies, some being liquids and some solids, possessing antiseptic properties. They are termed monohydric when they contain one hydroxyl group (directly connected to nuclear carbon atoms); dihydric when two are present; trihydric when three groups are present; and polyhydric when they contain many such groups. Catechol ($C_6H_4(OH)_2$) is a dihydric phenol; pyrogallol ($C_6H_3(OH)_3$) is represented as a trihydric member; and quercitol ($C_6H_7(OH)_5$) as a polyhydric phenol.

Ordinary phenol or carbolic acid (C_6H_5HO) is the active principle of crude carbolic acid as obtained from coal-tar fractional distillation, and an account of its manufacture from this material is described in the *Ind. Chem.*, 1929, v., 273. During the Great War large quantities of phenol were prepared synthetically from benzene, proceeding through benzene-sulphonic acid. Other processes for the synthesis of phenol are based respectively on the hydrolysis of monochlorobenzene by means of steam, and upon the direct oxidation of benzene in the vapour phase, using air in presence of a catalyst. The synthetic processes form part of the subject of No. 6, Technical Records of Explosives Supply, 1915-1918 (H.M. Stationery Office). (See also Phenol (synthetic), *C.T.J.*, 1927, **81**, 156, and R. T. Baldwin, *J.S.C.I.*, 1930, **49**, 70 T.)

In the pure state it is a white, poisonous, deliquescent, colourless, crystalline substance, of sp. gr. 1·08, b.p. 181·7° C., m.p. 41·5° C.; is soluble in water (1 : 15) at 16° C., and the crystals are liquefied by a little water. It is also readily soluble in alcohol and ether, possesses strong antiseptic properties, but is corrosive to the skin and very poisonous. It is used in the manufacture of disinfectant preparations, dyes, picric acid, salicylic acid, and other compounds, also in compounding synthetic resins.

Phenols of the naphthalene series are described as naphthols, and those from toluene as cresols. Phenolic bodies include cresol (C_7H_8O), xylenol ($C_8H_{10}O$), catechol ($C_6H_6O_2$), cumenol ($C_9H_{12}O$), carvacrol ($C_{10}H_{14}O$), guinol ($C_6H_6O_2$), and thymol ($C_{10}H_{14}O$). (See "Phenols Recovery" from Ammonium Sulphate Still Effluents, by D. W. Parkes, *J.S.C.I.*, 1927, **46**, 186 T; Carbolic Acid, and Tricresyl Phosphate.)

PHENOXIDES—See Phenolates.

PHENYL (C_6H_5-)—The univalent benzene nucleus or radical, as contained, for example, in phenol (C_6H_5HO).

PHENYLACETALDEHYDE ($C_6H_5.CH_2.CHO$)—A colourless liquid of sp. gr. 1·03 and b.p. about 192°; used in perfumery, having an odour like that of hyacinth; soluble in alcohol and ether.

PHENYLACETIC ACID ($C_6H_5CH_2CO_2H$)—A white, crystalline substance, soluble in alcohol and ether, used in perfumery; m.p. 76° C.

PHENYL HYDRAZINE ($C_6H_5NH.NH_2$)—A colourless crystalline body melting at 23° C. and reducible to aniline and ammonia.

PHENYLAMINE (**Aniline**) ($C_6H_5NH_2$)—See Aniline.

PHENYLENE—The divalent group—C_6H_4-.

PHENYLENE DIAMINE—The beta and para compounds ($C_6H_4(NH_2)_2$) are colourless crystalline substances, soluble in alcohol, ether, and water; used in perfumery and dyeing.

PHENYL-ETHYL ALCOHOL ($C_6H_5.CH(OH).CH_3$)—A secondary alcohol (analogous to the alcohols of the fatty series) which can be prepared synthetically, and is used in perfumery. It occurs to the extent of some 75 per cent. in rose oil, and is obtained by the maceration or extraction process, but not in that resulting from direct steam distillation. (See J. McLang, *C.T.J.*, 1926, **79**, 496.)

PHLOGOPITE ($3(K_2,H_2)O,6(Mg,Fe)O,(Al_2,Fe_2)O_3,6SiO_2$)—A micaceous mineral of crystal system, No. 5, and sp. gr. 2·8 to 3·2, constituting the main Canadian supply. (See Mica.)

PHLORIDZIN ($C_{21}H_{24}O_{10}2H_2O$)—A poisonous, crystalline glucoside of m.p. 109° C. found in the root-bark of apple, pear, plum, cherry, and other fruit trees, which upon hydrolysis yields phloretin ($C_{15}H_{14}O_5$) and grape-sugar; soluble in alcohol and hot water. (See papers on its constitution by Johnson and Robertson (*J.C.S.*, 1930, p. 21) and R. Weidenhagen (*B.C.A.*, 1931, A, 940).)

PHOSGENE—See Carbonyl Chloride.

PHOSPHATE ROCK—Surveys of the world's output of phosphate rock and superphosphate have been given by A. N. Gray. (See *C.T.J.*, 1926, **79**, 369, 722; 1929, **85**, 215; and 1932, **90**, 81; W. Stollenwerk (*B.C.A.*, 1927, B, 554); Coprolites, Superphosphate, Phosphorite, and Phosphorus.)

PHOSPHATES—Ground calcium phosphate of mineral nature used largely as a fertilizer, being sometimes usefully admixed with ground carbonate (chalk). The total consumption of phosphates in Europe reached 4,617,000 tons in 1924. (See C. H. Butcher on "The Water-soluble Phosphates" (*C.T.J.*, 1931, **88**, 247); Apatite, Bones, Coprolites, Phosphorus, and Redonda Phosphates.)

PHOSPHATIC MANURES—See Bones, Coprolites, Fertilizers, Phosphates, Superphosphate, and Slag.

PHOSPHATIDES—The International Union of Pure and Applied Chemistry have suggested the abandonment of this term and the substitution of the word "phospholipid" for lips containing phosphorus, and "phosphoaminolipid" for those containing phosphorus nuclei and amino nitrogen. (See Brain Matter and Glycerophosphoric Acid.)

"PHOSPHAZOTE"—See Fertilizers.

PHOSPHIDES—See Phosphorus Compounds.

PHOSPHINE—See Phosphorus Compounds, p. 699.

PHOSPHINES (Organic)—Feebly basic compounds prepared from phosphoretted hydrogen (phosphine) (PH_3) by the substitution of hydrogen with alkyl radicals—for example, triethyl phosphine ($P(C_2H_5)_3$). They correspond closely to the amines in composition.

PHOSPHITES—See Phosphorus Compounds.

PHOSPHOMOLYBDIC ACID—See Phosphorus Compounds, p. 701.

PHOSPHONIUM COMPOUNDS—See Phosphorus Compounds.

PHOSPHOR BRONZE—An alloy with a low coefficient of friction, used as a substitute for bronze and gun-metal in gearings, bearings, wire ropes, etc., composed of copper and tin fluxed with a variable quantity (up to 1 per cent.) of phosphorus, which is generally added in the form of copper phosphide or stannic phosphide. The existence of a ternary eutectic of m.p. 628° C., consisting of 80·7 per cent. Cu, 4·5 per cent. P, and 14·8 per cent. Sn, has been established. (See Glaser and Seemann, *B.C.A.*, 1926, B, 411.)

PHOSPHORESCENCE—See Light, Luminosity, Radium, and Zinc (Sulphide).

PHOSPHORETTED HYDROGEN (PHOSPHINE)—See Phosphorus.

PHOSPHORIC ACIDS—See Phosphorus Compounds.

PHOSPHORITE (Rock Phosphate of Calcium, $Ca_3(PO_4)_2$)—A variety of apatite.

PHOSPHORUS (P) **and its Compounds**—Atomic weight 30·98; m.p. 44° C. This element does not occur in nature in its free state, but abounds in combination as calcium phosphate in the seeds of plants and in soils, its presence in the latter being derived from the disintegration of rocks. Plants require phosphates as an essential to their proper growth and development, and the animal kingdom obtains its supply in turn from vegetable life. ("The Rôle of Phosphorus in Agriculture" is the subject of an article by E. Vanstone (*J.S.C.I.*, 1926, **45**, 78 T).) Phosphorus in various combinations is a constituent of many animal tissues, including brain matter, while the bones owe their rigidity to calcium phosphate, which makes up 60 per cent. of their substance. Bone ash, indeed, consisting as it does, in the main, of that substance, is one of the chief sources of phosphorus. (See Bones.) In various combinations as phosphate, it is present in the minerals *sombrerite* ($Ca_3(PO_4)_2$), *apatite* ($3Ca_3(PO_4)_2,CaF_2$), *wavellite* ($2Al_2(PO_4)_2,Al_2(HO)_6,9H_2O$), also in Gafsa phosphate, "Ephos," "Naura," "Buccaneer," and Coprolites. (See Coprolites and Superphosphate of Lime.)

Large deposits of rock phosphates are found in Tunisia, Algiers, the Pacific Islands, Morocco, Esthonia, the Somme (France), Florida, South Carolina, Egypt, Hokaidaito Islands (Japan), etc. Naura phosphate (New Zealand) contains about 85·28 per cent. tri-calcium phosphate, and North African about 63·35 per cent. The total output of phosphate rock in 1925 amounted to about 8,621,800 tons. (See Phosphates.)

Phosphorus is made from bone ash or sombrerite by treatment with

PHOSPHORUS (*Continued*)—

sulphuric acid of sp. gr. about 1·5, when the following interaction takes place:

$$Ca_3(PO_4)_2 + 3H_2SO_4 = 3CaSO_4 + 2H_3PO_4$$

—that is to say, insoluble calcium sulphate and phosphoric acid (in solution) are produced, and after filtration of the mixture, the liquid filtrate is concentrated by evaporation and yields the acid in crystalline form of deliquescent nature. From the acid so prepared, phosphorus may be obtained by mixing it with powdered charcoal, heating, and subsequent distillation; at first, the phosphoric acid is broken up into water and meta-phosphoric acid as follows, $H_3PO_4 = H_2O + HPO_3$; and at a later stage there is a further change by which this acid is decomposed ($4HPO_3 + 12C = 12CO + 2H_2 + 4P$), the phosphorus being condensed in dark yellow drops under water, in which it subsequently solidifies. It is now chiefly produced by the less wasteful and more economical "Readman" process in which silica takes the place of sulphuric acid.

It is also manufactured from a mixture of calcium phosphate and carbon by use of the electric furnace, calcium carbide being formed at this high temperature, and phosphorus being set free (in vaporous form associated with carbon monoxide gas) and subsequently condensed ($Ca_3(PO_4)_2 + 14C = 3CaC_2 + 2P + 8CO$). Silica may be mixed with the coke.

In the pure state, phosphorus is a slightly yellowish-white, semi-transparent, wax-like substance, which takes fire when warmed and exposed to the air, so that it has to be kept submerged in water. (See Ozone, p. 657.) In its ordinary form it is very poisonous, has a sp. gr. of 1·83, and is soluble in carbon disulphide (CS_2), from which it may be obtained upon evaporation in the form of colourless crystals. It may also be sublimated *in vacuo* and obtained in beautiful crystals.

Kingzett has shown that when phosphorus is oxidized by means of air or oxygen while partly submerged in water not only is ozone produced (as was formerly supposed), but that hydrogen dioxide is also produced (as was not previously known) (*J.C.S. Trans.*, December, 1880, p. 792).

The glow of phosphorus exhibited during its slow oxidation, its inhibition, and some other features have been studied by H. J. Emeléus (*J.C.S.*, 1926, p. 1336); H. J. Emeléus and R. H. Purcell (*Ibid.*, 1927, p. 788; C. C. Miller (*Ibid.*, 1929, pp. 1820 and 1823); and Bowen and Cavell (*Ibid.*, 1929, p. 1920).

Phosphorus is allotropic—that is to say, it can be made to assume more than its ordinary almost colourless waxy form. When heated to between 240° and 250° C. out of contact with the air, it passes into a red form, which has a sp. gr. of 2·2, and, unlike the ordinary yellow phosphorus, is not luminous in the dark, and is not poisonous. A mixture of the two forms is produced by the rapid cooling of phosphorus vapour, but only the yellow form by slow cooling. A black form resulting from long exposure to light is changed into the scarlet form

PHOSPHORUS (*Continued*)—

on being heated to 575° C., and the melting-point of the red variety has been recently determined as 592·5° ± 0·5° C. (See V. N. Ipatiev (with others) on "Allotropy of Phosphorus" (*B.C.A.*, 1931, A, 898).)

Phosphorus is largely used in match-making, the preparation of rat-poison, and the manufacture of *phosphor bronze.*

It forms several compounds with hydrogen, the better known being hydrogen phosphide (PH_3) (phosphine or phosphoretted hydrogen), which is formed when red phosphorus is gently heated in a current of hydrogen gas; also by the action of caustic potash on phosphorus, or by the action of water upon calcium phosphide:

$$3Ca_2P_2 + 12H_2O = 6CaH_2O_2 + 4PH_3 + 2P.$$

This is a colourless, highly poisonous gas, soluble in alcohol and ether, of offensive garlic-like odour, and spontaneously takes fire at a temperature below that of boiling water.

Calcium phosphide is employed in the construction of drain-testers, and the action of water upon that substance finds practical employment also in the marine appliance known as Holmes's signal. In the case of the drain-testers, the distinctive odour of the gas enables the operator to detect leakages in drains, whilst in the case of Holmes's signal, the phosphoretted hydrogen ignites and burns, giving a considerable illumination.

Hypophosphorus Acid (H_3PO_2) is a white crystalline body (m.p. 17·4° C.), obtained by decomposing its barium salt ($Ba(H_2PO_2)_2$) with sulphuric acid, the barium compound in its turn being prepared by boiling phosphorus in a solution of barium hydroxide.

Several of the hypophosphates, including the potassium, sodium, and calcium salts, are used in medicine.

Phosphoric Acid (**Ortho-phosphoric Acid,** H_3PO_4) is put up in various forms—viz., liquid of sp. gr. 1·23 to 1·63 and containing 66·3 H_3PO_4 (B.P. Standard); in paste containing 40 to 50 per cent.; and in crystalline form (m.p. 38·6° C). Its salts (phosphates) are obtained by neutralization with alkali to the required point and crystallization. It finds employment in defecating sugar, and in the glass and mineral water industries, etc., and can be used for making monocalcium phosphate and other fertilizers of greater concentration than ordinary "superphosphate," also disodium phosphate. Ordinarily it has been made in the past by the action of sulphuric acid upon tricalcium phosphate (bone ash).

In the "Liljenroth" process, phosphate rock is reduced with coke and some silicate in an electrical furnace, giving phosphorus, the vapour of which together with steam is passed over a catalyst at about 1,000° C., hydrogen being set free as a by-product. This can be used for ammonia synthesis and the ammonia combined with the phosphoric acid to form ammonium phosphate. (See C. F. Hammond on "Concentration of Phosphoric Acid" (*Chem. and Ind.*, 1931, **50,** 733).)

There is a pyrolitic method of producing phosphoric anhydride—viz.,

PHOSPHORUS (*Continued*)—

by smelting mixtures of phosphate rock, sand, and coke, and collecting the fumes of the generated acid by means of the Cottrell precipitating plant. This process is likely to prove much less costly than the sulphuric acid process. (See K. D. Jacob, *C.T.J.*, 1925, **77,** 353.)

Phosphoric acid, in the form of soluble phosphates, enters into the composition of many medicines, such as chemical foods and nerve stimulants: phosphates are also used in the dyeing and bleaching trades, the fireproofing of woods, and in sugar-refining. The natural phosphates, with or without treatment, are largely used in agriculture as fertilizers, and it is claimed that rock phosphates give equal results to those secured from the high citric-soluble types of basic slag.

Wagner found that if 5 grammes of a phosphatic material were treated with 10 grammes of citric acid under certain defined conditions of temperature and dilution, the amount of phosphoric acid passing into solution bore a direct linear relationship to the fertilizing value of the material, and for high-grade slags this test was satisfactory. It has, however, proved to be not so with other grades and lower soil-soluble phosphates, and Robertson has arrived at the conclusion that if 1 gramme of phosphate be used in this test to the 10 grammes of citric acid, a far more accurate indication is secured.

The availability of any particular phosphate depends in some degree upon the manner and the extent to which it takes part in the various soil reactions—that is to say, their fertilizing values must bear some definite relation to their relative solubility in soil solution. (See W. H. Ross (*Ind. Eng. Chem.*, 1922, **14,** 533; and Slag (p. 499).)

Phosphorus Acid (H_3PO_3) is a white crystalline body (m.p. 70·1° C.), formed by dissolving phosphorus oxide in water or by the action of water upon phosphorus trichloride: $PCl_3 + 3H_2O = 3HCl + H_3PO_3$. It is dibasic, and forms two classes of salts (phosphites).

Meta-phosphoric Acid (**Glacial Phosphoric Acid,** HPO_3) is a highly deliquescent glacial compound resulting from the deliquescence of phosphorus pentoxide, and can be obtained by heating ortho-phosphoric acid to redness, by which it loses a molecule of water: $H_3PO_4 - H_2O = HPO_3$. It is used in pharmacy and medicine.

Pyrophosphoric Acid ($H_4P_2O_7$ is a white crystalline body, soluble in water, which can be prepared in a number of ways, as, for example, by heating the ortho-acid to 213° C., when it loses a molecule of water, yielding the pyro-acid: $2H_3PO_4 - H_2O = H_4P_2O_7$.

Two perphosphoric acids are known to exist—namely, H_3PO_5 and $H_4P_2O_8$, the former being prepared by the action of 30 per cent. hydrogen dioxide (H_2O_2) solution on phosphorus pentoxide, and the acid $H_4P_2O_8$ by the same reagent acting on syrupy phosphoric acid.

All these acids and a number of their salts are used industrially.

"Hypophosphoric" acid is stated to be formed by oxidation of red phosphorus with alkaline permanganate or peroxide of hydrogen, the sodium salt being represented by $NaHPO_3$ (F. Vogel, *B.C.A.*, 1929, B, 525).

PHOSPHORUS (*Continued*)—

There are a number of oxides of phosphorus, of which the more important are the trioxide and the pentoxide.

Phosphorus Trioxide (P_4O_6), a white, non-crystalline powder, is formed by burning phosphorus in a limited current of dry air; m.p. 23·8° C. (See C. C. Miller, *J.C.S.*, 1928, p. 1847.)

Phosphorus Pentoxide (P_2O_5) is formed when phosphorus is burned in excess of air or oxygen, and is a white sublimable powder, used as a dehydrating agent (having a great affinity for water), also in sugar-refining.

Phosphomolybdic Acid ($H_3PO_4,12MoO_3$)—A yellow, crystalline substance soluble in water, used chemically as a reagent in the examination and preparation of alkaloids.

Phosphorus Trichloride (PCl_3) is a colourless, fuming liquid, and the pentachloride (PCl_5) is a yellow, crystalline body, both of which are made by the action of chlorine upon phosphorus, and are used as chlorinating agents; both are soluble in carbon disulphide.

Other compounds of phosphorus (salts of phosphine) include phosphonium chloride (PH_4Cl), phosphonium bromide (PH_4Br), phosphonium iodide (PH_4I) (all of which are crystalline bodies), and two fluorides (PF_3 and PF_5).

PHOSPHORYL—The trivalent radical ⋮P : O, as it exists in combinations such as phosphoryl chloride ($POCl_3$)—a colourless, fuming liquid formed by the action of water upon phosphorus pentachloride, etc.

PHOTO-ACTIVATION—See Photo-catalysis, Photo-chemistry, and Ultra-Violet Rays.

PHOTO-CATALYSIS and PHOTO-SYNTHESIS—Reactions induced by energy and a catalytic substance, brought about by exposure to light or certain rays of light, and "there is analogy, if not identity, between actinic light energy and the electrolyzing power of an electric current" (F. Scholefield, *Chem. and Ind.*, 1930, **49,** 895).

The formation of formaldehyde from carbon dioxide and water in the living chloroplasts of plant life is a purely photochemical one, and by the action of ultra-violet light, formaldehyde is readily polymerized to sugar. Employing the same source of energy, certain alkaloids (peculiar products of vegetable anabolism) have been built up from formaldehyde and nitrites or ammonia, and some complex carbohydrates from carbon dioxide and water with the aid of certain catalysts and without the intermediate formation of formaldehyde (see E. C. C. Baly, September issue of Proceedings of the Royal Society, 1927, and Carbohydrates, p. 137). By exposing nickel carbonate (which is known to absorb carbon dioxide) to ultra-violet light, Baly has obtained a syrup which gives all the reactions of glucose. Better results were obtained by substituting ferric oxide (containing some thorium oxide as promoter) deposited on aluminated Kieselgühr,

PHOTO-CATALYSIS (*Continued*)—
as these powders require no previous activation. The relation of these results to the production of carbohydrates in plant life is of high importance, and it is not at all unlikely that at some future time practical advantage may be taken of extended knowledge of such processes in the manufacture of synthetic foods, making mankind more or less independent of animal and vegetable foods.

The activated formaldehyde produced as above described reacts with potassium nitrite to produce formhydroxanic acid, and this, by interaction with more of the activated formaldehyde, gives rise by a process of condensation to various nitrogen compounds. The various amino-acids, proteins, alkaloids, etc., are therefore regarded by recent investigators as the inevitable result of the photo-synthesis of formaldehyde in the presence of potassium nitrite. It is further concluded that the synthetic processes are restricted to the leaves, the formation of the hexoses occurring at the same time.

In these various processes, oxygen is at the same time evolved, and it is observable that as the enzyme catalase is present in the leaves, it is this enzyme that possibly causes the reduction of potassium nitrate to nitrite. It is to be noted, however, that there are many lower plants which, by the reduction of carbon dioxide, obtain all their carbon in the dark without assistance by radiation, and synthesize the whole of their organic constituents from that source, chemical energy here replacing radiant energy. These interactions are termed "chemosynthetic."

Chlorophyll forms additive compounds with carbon dioxide, and the complex so formed under the influence of visible light produces formaldehyde.

Apart from the influence of any catalyst, many photo-chemical changes can be effected by the radiant energy of ultra-violet light or strong sunlight. Toluene, for example, in admixture with water and anthra-quinone, is oxidized to the extent of 30 per cent. to benzoic acid. Glyoxal ($C_2H_2O_2$), b.p. 50° C., a volatile yellow liquid, under illumination from the mercury-vapour lamp through glass, decomposes in the main into carbon monoxide and a solid product, $2C_2H_2O_2 - CO + C_3H_4O_3$ (Norrish and Griffiths, *J.C.S.*, 1928, p. 2829). Other changes are referred to under the heading of Ultra-Violet Rays. A large amount of photo-synthesis is obtainable by the agency of moonlight.

Photo-synthesis is the subject of books by W. Stiles (Longmans, Green and Co.) and H. A. Spoehr (Chem. Catalog. Co., Inc., N.Y.). See also Light, Photo-chemistry, Plant Colouring Matters, Ultra-Violet Rays, and Vegetation.

PHOTO-CHEMISTRY is the study of chemical changes induced by light or radiant energy. It is now possible, using an ordinary camera, to obtain coloured films reproducing the actual colours of the objects photographed. Chatterji and Dhar have shown that chloroform in an enclosed glass vessel exposed to tropical sunlight is oxidized to the extent of 2½ per cent. in two to three hours (*B.C.A.*, 1930, A, 1385). Wulff and Seidl regard adsorption as the primary process of photographic development (*B.C.A.*, 1930, A, 1534).

PHOTO-CHEMISTRY (*Continued*)—

Other references: H. Baines on the preparation of emulsions and films (*Chem. and Ind.*, 1930, **49**, 1003), and the "Mechanism of the Photographic Process" (*Ibid.*, 1931, **50**, 256); A. C. Brooke on "Lantern Slides" (*J. Inst. Chem.*, August, 1930); T. Slater on "Photographic Sensitivity" (*J.S.C.I.*, 1927, **46**, 145 T); F. C. Hymas on "Correlation of certain Photo-chemical Reactions and Wave-lengths of Light" (*J.S.C.I.*, 1931, **50**, 81 T and 193 T); H. Baines on "New Methods of Analysis of Photographic Products" (*J.S.C.I.*, 1929, **48**, 295-304 T); "The Chemist in the Photographic Industry," by O. F. Bloch (Inst. of Chemistry publication); W. Clark on production of a photographic image by the aid of lantern slides and films (*Chem. and Ind.*, 1929, **48**, 1178); M. Bodenstein on "Chemical Action of Light" (*Chem. and Ind.*, 1930, **49**, 139); Photo-engraving (*Ind. Chem.*, 1931, vii., 233); Allmand and Beesley on "Photo-chemical Union of Hydrogen and Chlorine" (*J.C.S.*, 1930, pp. 2693-2721); H. Baines on "Sensitometry" (*Chem. and Ind.*, 1931, **50**, 706, and *Ibid.*, 1932, **51**, 175); Photo-chemical Processes—general discussion (Faraday Soc., April, 1931); *Photography: its Principles and Practice*, by C. B. Neblette (Chapman and Hall, Ltd.); *Photographic Printing Processes*, by O. Wheeler (Chapman and Hall, Ltd.); *Photo-processes in Gaseous and Liquid Systems*, by Griffith and McKeown (Longmans and Co.); *Photo-chemical Processes*, by G. B. Kistiakowsky (Chem. Catalog. Co., Inc., N.Y.); Light (p. 535), and Photo-catalysis.

PHOTOGEN—A name sometimes given to the light hydrocarbon oils (obtained from the distillation of coal, peat, and shale at low temperatures) which are used for burning in lamps.

PHOTOMETERS—Instruments for measuring the intensity of light. For description of one type for comparing the whiteness of fabrics see A. Adderley (*J. Text. Inst.*, 1929, **20**, T. 203); see also F. Twyman on the "'Spekker' Photometer" (*Chem. and Ind.*, 1931, **50**, 868).

PHOTOMETRIC ANALYSES—See Colorimeters and Nephelometry.

PHOTONS—A term introduced to represent the hypothetical existence of new kinds of corpuscles resulting from the annihilation of atoms and constituting forms of radiant energy persisting after absorption as an essential constituent of the absorbing atoms. (See *Nature*, 1926, **118**, 874; "Progress of Science," *The Times*, p. 8, July 20, 1931; report of Sir James Jeans' recent lecture in *The Times*, December 3, 1931; Atoms, Electrons, Force, and Matter.)

PHOTOPHONE—Instrument for communicating sounds by means of a beam of electric light or sunlight; the transmitted sound can be heard at a considerable distance from the source of the transmitted speech.

PHOTO-SYNTHESIS—See Photo-catalysis.

PHTHALEÏNS—A group of dyes, including phenolphthaleïn and fluoresceïn, containing two phenol residues: prepared by action of phenols

PHTHALEÏNS (*Continued*)—

on phthalic anhydride, and nearly related to another colourless group known as "phthalines" (leuco-compounds of the phthaleïns).

PHTHALIC ACID ($C_8H_6O_4$ or $C_6H_4(CO_2H)_2$)—A colourless crystalline substance, readily soluble in alcohol and ether, which is made commercially by oxidizing naphthalene with fuming sulphuric acid in the presence of a small quantity of mercury at 220° to 230° C. It melts at 213° C., and is used in the synthetic production of indigo, etc.

PHTHALIC ANHYDRIDE ($C_6H_4(CO)_2O$)—A white crystalline body, m.p. 128° C., used in preparing eosin dyes, etc.; soluble in alcohol, and obtained by distillation of phthalic acid, or warming the acid with acetyl chloride, etc. It is commercially prepared by oxidation of naphthalene with concentrated sulphuric acid containing mercury sulphate, or oxide or metal, which acts catalytically, the sulphur dioxide formed in the process being reconverted into sulphuric acid by air: vanadium catalysts are said to have proved most efficient. An account of its production by catalytic oxidation in the vapour phase is given by C. R. Downs (*J.S.C.I.*, 1926, **45**, 190 T). Synthetic resins can be made from phthalic anhydride condensed with glycerol. (See T. H. Barry, *Ind. Chem.*, 1928, iv., 53.)

PHTHALIMIDE—See Imides.

PHYSICAL CHEMISTRY—See introductory books by F. B. Finter (Longmans, Green and Co.); and by O. Maass (Chapman and Hall, Ltd.); *A Treatise on Physical Chemistry*, by a group of physical chemists, edited by H. S. Taylor (Macmillan and Co., Ltd.); *Textbook of Physics*, by A. Wilmer Duff (J. and A. Churchill); *Theoretical and Experimental Physical Chemistry*, by Crocker and Matthews (J. and A. Churchill); *Physical and Inorganic Chemistry—Recent Advances in*, by A. W. Stewart (Longmans, Green and Co.); *Recent Advances in*, by S. Glasstone (J. and A. Churchill); *Handbook of Chemistry and Physics* (Chemical Rubber Publishing Co., Cleveland, Ohio); *Practical Physical Chemistry*, by A. Findlay, fifth edition (Longmans, Green and Co., Ltd.); also Atoms, Electricity, Elements, Force, Heat, Light, and Matter.

PHYSICAL CONSTANTS—See Constants.

PHYSIOLOGICAL CHEMISTRY—See Biochemistry.

PHYSOSTIGMINE ($C_{15}H_{21}N_3O_2$)—A crystalline base of m.p. 102° to 103° C., insoluble in water, but soluble in alcohol, ether, and chloroform. (See M. Wagenaar (*Analyst*, 1929, **54**, 424), and Calabar Bean.)

PHYTOSTEROLS—See Sterols and Yeast.

PIASSAVA—A fibre derived from the leaf stalks of the two palms (*Raphia Vinifera* and *Raphia Gaertneri*) of Sierra Leone (Southern and Central Provinces); used in making coarse brooms. (See Raphia.)

PICHURIM BEANS (*Fabæ pichurim minores*, from *Ocotea pichura minor*, Martius) yield upon distillation with water a yellow oil with an odour like that of bay and sassafras oils, containing terpenes and a

PICHURIM BEANS (*Continued*)—
camphor, together with lauric acid ($C_{12}H_{24}O_2$). The Brazilian beans yield 2·1 per cent. oil of d^{15} 1·0538, acid v. 9·7, and ester value 4·6.

PICKLING—See Galvanizing and Rustless Iron.

PICOLINES [$C_5H_4N(CH_3)$]—Methyl-pyridines (three) contained in bone oil.

PICRAMIC ACID (**Dinitro-amino-phenol**) ($C_6H_2(NO_2)_2NH_2OH$)—A red, crystalline substance, soluble in alcohol and ether, which melts at 168° C., and is used in azo-dyestuffs.

PICRIC ACID ($C_6H_2(NO_2)_3OH$) (**Tri-nitro-phenol**)—A poisonous, lemon-coloured, crystalline substance (m.p. 122° C.), largely used in the manufacture of explosives and as a yellow dye for silk and wool; prepared by the graduated action of strong nitric acid upon phenol, also by the nitration of monochlorobenzol in the presence of sulphuric acid and by the nitration of phenolsulphonic acid, using strong nitro-sulphuric acid, etc.

During the war, large quantities were prepared by converting benzene into dinitrochlorobenzene, and treatment of the product with caustic soda, whereby it is converted into dinitrophenolate, and this, on further treatment with acid, yields dinitrophenol, which in turn is converted into picric acid by nitration with strong acid. Another process is that of heating a mixture of benzene, mercuric nitrate, and nitric acid at 50° to 60° C. (See L. Desvergne's description of this process, *B.C.A.*, 1930, B, 8.)

It explodes with violence when heated or struck, is soluble in alcohol and sparingly soluble in water, to which it gives a deep yellow colour. Its melting temperature is reported to be an objection to its use as a high explosive; moreover, on solidifying from a melted state cavities are formed. (See Explosives, p. 330.)

PIEZOMETER—Appliance for determining compressibilities of substances.

PIGMENTS—See A. P. Laurie on "Identification of Pigments used in Painting at Different Periods" (*Analyst*, 1930, **55**, 162); F. Schmid on "Physical Tests for Pigments" (*B.C.A.*, 1930, B, 248); N. Heaton on "Modern Mineral Pigments" (*C.T.J.*, 1931, **89**, 473); H. Meier on "Oil Absorption of Pigments" (*B.C.A.*, 1932, B, 117); *Artificial Organic Pigments,* by C. A. Curtis (Pitman and Sons); *The Manufacture of Lakes and Precipitated Pigments,* by A. W. C. Harrison (Leonard Hill, Ltd., London); also Carbon (p. 139), Colour, Colouring Matters, Dyes, Lakes, Iron Oxides, Mineral Black, and Paints.

PILCHARD OIL—See Fish Oils.

PILI NUT OIL, from the seeds of *Canarium oratum,* is edible and composed of glycerides in proportions of oleic 59·6, palmitic 38·2, and stearic 1·8. Its sp. gr. at 30°/4° is 0·9069; i.v. (Hübl), 55·9; sap. v., 197·4; and acid value, 1·42.

PILOCARPINE—A poisonous alkaloid of lactonic nature, contained in the leaves and stalks of *Pilocarpus jaborandi,* indigenous in Brazil.

PILOCARPINE (*Continued*)—
According to M. Wagenaar, pilocarpine is normally a colourless, viscid liquid, very soluble in water, alcohol or chloroform but almost insoluble in ether, and it produces an amorphous sublimate, although otherwise it is stated to have a m.p. of 34° C. It is represented by the formula $C_{23}H_{35}N_4O_4$ as first ascertained by Kingzett from analyses of the alkaloid and a platinic crystalline compound ($C_{23}H_{35}N_4O_4,2HCl, PtCl_4$), or $C_{11}H_{16}N_2O_2$, as determined subsequently by Jowett, accompanied by another alkaloid named pilocarpidine ($C_{10}H_{14}O_2N_2$).

Other varieties are imported from Paraguay, Rio, etc. It is used in medicine and compounding hair tonics.

PIMARIC ACID—See Abietic Acid.

PIMELITE—Native green nickeliferous silicates.

PIMENTO OIL (**Pimenta Oil, Allspice Oil**)—A colourless or slightly yellow, heavy, volatile oil (yield 3·5 per cent.) distilled from the unripe fruit of *Eugenia pimenta* of the West Indies. Its ref. ind. is 1·53 at 25° C., opt. rot. 0° to 4° k. at 20° C., and sp. gr. 1·045 to 1·055 at 15° C. It darkens and thickens upon exposure to the air, and resembles oil of cloves in odour; is soluble in alcohol and ether, and used in perfumery and for flavouring.

The leaf oil from *Pimenta officinalis* is stated to contain 95·5 per cent. eugenol associated with caryophyllene. A sample obtained from the leaves of the wild Jamaica plant has been reported as having a sp. gr. of 0·8895 at 15° C.

"PINACYANOL"—A dyestuff that sensitizes photographic plates far into the red region of the spectrum.

"PINA-KRYPTOL"—A mixture of a colourless compound with a small proportion of the green dye "pina-kryptol green," used as a photographic desensitizer.

"PINAVERDOL"—An isocyanine dyestuff used for sensitizing photographic plates through the green and well into the red region of the spectrum.

PINCHBECK—An alloy gold-like in appearance consisting of copper and zinc in varying proportions—about 3 oz. zinc to 1 lb. copper or 1 part zinc and 8 parts copper.

PINE OIL—A name variously used, but originally applied to the turpentine-like oils obtained from pine and fir trees, particularly those from the seeds and needles. These vary in their odours, drying properties, and rotatory powers, etc. The oil from *Pinus pumilio* needles is used in medicine, and is one of the best known of this class, having an agreeable balsamic odour, of sp. gr. 0·863 to 0·875, and rotation −6° to −14°. (See a description of pine-needle oil from Crimean *Pinus halepensis* Mill, by B. Rutovski and I. Vinogradova (*B.C.A.*, 1929, B, 536); that of the essential oil of white pine, by H. A. A. Aitken (*J.S.C.I.*, 1929, **48,** 345 T; that of the essential oil of silver pine (*Dacrydium Colensoi*), by W. J. Blackie (*J.S.C.I.*, 1929, p. 357 T); and "The Constituents of Dwarf Pine Oil," by Winehaus and Nahowe (*B.C.A.*, 1929, B, 1049).)

PINE OIL (*Continued*)—

The name is also given in commerce to a crude kind of turpentine obtained in the U.S.A. by the dry destructive distillation of pine wood (now practically out of use) and the so-called steam or steam and solvent method. The "light-wood" used comes largely from the *Pinus palustris*, *Pinus heterophylla*, and *Pinus echinata*, although any wood rich enough in resinous material can be used; a yield of from 10 to 17 gallons per cord being obtained under the best conditions. It contains terpenes, terpineol and a number of other substances, even when obtained by the steam method, and in the case of destructive distillation the oil is associated with those resulting from the cracking of both the wood-tar and rosin. The steam product has a density of from 0·92 to 0·945 at 20° C., ref. ind. of 1·4820 to 1·4870, and exhibits a germicidal property of considerable power in respect of organisms of the typhoid group and some others, but is less efficient against *Micrococcus aureus* and other common pathogenic organisms.

So-called "Huon" pine oil is produced in Tasmania by the steam distillation of chips and sawdust from the wood of *Dacrydium franklini*. It is yellow to brown in colour and said to contain about 95 per cent. methyleugenol; sp. gr. 1·048 and refined 1·532.

Another variety (used in the manufacture of terpineol) is obtained as a by-product in the manufacture of pine wood-pulp by the "sulphate" process, 45 kg. of oil being obtained per 1,000 kg. of sulphate cellulose. After purification, the refined Swedish oil has a viscosity of 334 to 4,000, a sp. gr. at 15°/4° C. of 0·967 to 1·001; contains resin acids 34 to 53 per cent., and fatty acids 29 to 51 per cent. Its technical value is said to depend largely upon the removal of the resinous and fatty acid constituents. The name of pine oil is further applied to a refined rosin oil obtained as a product of the destructive distillation of resin. (See *C.T.J.*, 1930, **87**, 177 and 198; W. Fermazin (*B.C.A.*, 1931, *B*, 876); Rosin Oil and Turpentine.)

PINE-CONE OIL—See Turpentine.

PINE-LEAF OIL—See Turpentine.

PINE-NEEDLE OIL—See Pine Oil.

PINE-TAR OIL is a distillate of pine tar which darkens to a reddish-brown colour on keeping. It has a strong tarry, sharp odour, and is a very complex mixture resulting from the destructive distillation of the tar. Its average sp. gr. is 0·970; it is soluble in turpentine, and is sometimes used in ore concentration by the flotation process.

PINENE (**Australene**) ($C_{10}H_{16}$)—A terpene constituent of American and Spanish turpentines, pine oil, and some other essential oils; sp. gr., 0·8587; b.p. 156° C. When *a*-pinene is oxidized by potassium permanganate the chief product is pinonic acid ($C_{10}H_{16}O_3$), which upon further oxidation yields pinic acid, from which norpinic acid can be obtained. (See Shopper and J. L. Simonsen, *Chem. and Ind.*, 1929, **48**, 730; and Hydrocarbons (Terpenes).)

"PINKING"—See Motor Spirit.

PINOLINE—See Rosin Spirit.

PIPECLAY—A peculiar variety of clay found in Cornwall, Dorsetshire, and Devonshire, used for making tobacco pipes, certain kinds of pottery, and for whitening soldiers' belts, etc.

PIPER (**Piper Nigrum**)—See Pepper Oil.

PIPERIDINE ($C_5H_{10}NH$)—A colourless, liquid amine of basic character, smelling something like pepper and found in pepper in association with piperic acid ($C_{12}H_{10}O_4$) as the alkaloid *piperine* ($C_{17}H_{19}NO_3$). It boils at 106° C., is soluble in water and alcohol, and yields crystalline salts.

PIPERINE—A crystalline alkaloid ($C_5H_{10}N.C_{12}H_9O_3$), of m.p. 129° C., occurring in black pepper to the extent of from 5 to 15 per cent.; also in oil of cubebs. It breaks up by the action of alcoholic potash into piperidine and piperic acid. Pepper owes its taste to the piperine content. (See Heliotropin and Piperidine.)

PIPERITONE ($C_{10}H_{16}O$)—A ketonic constituent of the eucalyptus oils yielded by the *Eucalyptus piperita* and *E. dives*, and present in some to the extent of from 40 to 50 per cent. Pure *l*-piperitone may be obtained from these oils by treatment with a concentrated solution of resorcinol or sodium salicylate, followed by steam distillation (see S. Kimura, *B.C.A.*, 1930, A, 1294). Both menthol and thymol can be prepared from it by processes of reduction and oxidation respectively. *d*-Piperitone is also one of the main constituents of the essential oil from *Andropogon Iwarancusa* (Jones), a grass which grows in the Himalayas and Assam. Optically active piperitone undergoes racemization during formation of most of its common derivatives. (See Read (with others) (*J.C.S.*, 1929, p. 2068); and Thymol.)

PIPERONAL ($CH_2O_2:C_6H_3.CHO$) (**Artificial Heliotrope**)—See Heliotropine and Safrol.

PIPETTES are glass tubes, with or without bulbs, used for transferring given measures of liquid from one vessel to another, and are made to hold definite quantities, such as 5 c.c., 10 c.c., 20 c.c., 25 c.c., 50 c.c., and 100 c.c., being graduated on the stem. In practice, they are filled up to the graduated mark by dipping the lower end into the liquid and sucking up with the mouth.

A filtration pipette for spot indicator tests is described by E. R. Caley (*Ind. Eng. Chem.* (analytical edition), Vol. 2, No. 1, p. 77); gas absorption pipettes by A. O. Jones (*J.S.C.I.*, 1926, **44,** 115 T) and Egerton and Pidgeon (*B.C.A.*, 1931, A, 1388) respectively; a safety type to prevent the risk of sucking into the mouth (*Ind. Chem.*, 1926, ii., 282); another by E. Ott (*B.C.A.*, 1930, B, 975); a semi-automatic filling pipette for the delivery of constant volumes by V. B. Connell (*Ind. Chem.*, 1925, i., 276); automatic devices (*Ibid.*, 1928, iv., 388, and *J.S.C.I.*, 1928, **47,** 368 T); another automatic form intended for filling by means of air-pressure (*Analyst*, 1929, **54,** 737); a new design by H. M. Ridyard (*J.C.S.*, 1928, p. 749); one for removal of supernatant fluids (N. Gavrilesco, *B.C.A.*, 1931, A, 705); "A Simple Pipette for Micro-Filtration" (R. Edgeworth-Johnstone, *J.S.C.I.*, 1931, **51,**

PIPETTES (*Continued*)—

182 T); and "A Syringe-Pipette for Precise Analytical Usage," by Krogh and Keys (*J.C.S.*, 1931, p. 2436).

"PIPETTOR"—A device for automatically working pipettes. (See *Chem. and Ind.*, 1926, **45,** 759.)

PISTACHIO OIL—See Dhingra and Hilditch (*J.S.C.I.*, 1931, **50,** 9 T).

PITCH is a generic name applied to a number of products more or less identical in character but variously produced.

Gas-Tar Pitch or **Coal-Tar Pitch** is the residue left in the retorts from the distillation of gas tar, of which about 550,000 tons are annually produced in the United Kingdom. It finds use in roofing, as a binding material in the making of briquettes and joining up wooden road-paving blocks, also in making a black, coarse varnish and for insulating applications, etc. Water-gas pitch differs from horizontal retort pitch in having a lower "free carbon" content. The qualities which make pitch more suitable for fuel briquetting have been studied by the Fuel Research Board (see their Report for 1928 (H.M. Stationery Office); see also Tar, p. 896), and it has been found that the viscosity decreases steadily with increase of temperature, and that it is increased by melting and again cooling.

Workers in the tar and pitch industries in this country are more or less subject to epitheliomatous cancer, while in France there is comparative immunity, but to what extent this depends upon differences in the chemical constitution of the several pitches or the heavy oils and residues of tar distillation is not known. E. L. Kennaway has tentatively advanced the view that the cancer-producing material is formed by the heat polymerization of acetylene.

The matter of free carbon formation in pitches is dealt with in a paper by Adam and Sach (*J.S.C.I.*, 1929, **48,** 337 T).

"Cellactite" is the name given to a product made from ordinary hard pitch, which, with an equal weight of water, is fluid, and said to have great penetrative and covering power very suitable for mixing with asbestos or cellulose fibre prior to felting, etc.

Rosin Pitch is that left behind from the destructive distillation of rosin, and can be used for the same purposes as coal-tar pitch.

There are also varieties of pitch left behind from the distillation of shale, wood, petroleum oils, and blast-furnace oil.

Stearine Pitch, obtained as a residual from the distillation of fatty acids, is hard, bright, has a peculiar odour, and an iodine value of 50/70, which distinguishes it from petroleum and asphalt pitches. It is used in the manufacture of black enamels and flooring materials. (See Stearin.)

Wool Pitch is the residue left in the still after distillation of wool-fat, the process being generally finished at between 315° and 371° C. It is odourless and is made in several forms—liquid to medium-hard—the harder variety melting at about 38° C. It is chiefly used for making hot neck greases for tinplate roll mills; also for insulating purposes and in paper manufacturing.

PITCH (*Continued*)—

Burgundy Pitch is not a "pitch" in the same sense. (See Burgundy Pitch.)

The various classes of pitch are different in some respects, but consist in the main of hydrocarbons, and all of them find employment particularly in the preparation of waterproofing materials. The Metroplastimeter is a device for taking measurements of the consistency of pitch at ordinary temperatures. (See "The Evaluation of Pitch," by H. F. Taylor (*J.S.C.I.*, 1926, **45,** 417 T); and "Pitch Softening Points," by R. G. W. Eadie (*Ibid.*, 1927, **46,** 109 T); also Briquetting, Tar, and Wool Pitch.)

PITCH BINDER—See Prodorite.

PITCH-BLENDE (**Uraninite,** $UO.U_2O_3$), a mineral of crystal system, No. 1, and sp. gr. 6·4 to 9·7; used as the chief source of helium, radium, and uranium compounds. (See Uranium.)

"PITOXYLIN"—A preparation made from the pituitary gland.

PLANCK'S CONSTANT—See Quantum Theory.

PLANKTON—The drifting microscopic life of the sea.

PLANT (**Chemical**)—See Chemical Plant.

PLANT COLOURING MATTERS occur in the forms of so-called "plastid pigments" in the chloroplasts or granules of the cells. They include chlorophyll, carotene, etc. (which are intimately associated with the organized protoplasmic structure of plants), and the soluble "sap pigments," the latter class being divisible into two main classes—viz., (1) derivatives of flavone (flavonal)—sometimes named anthoxanthenes—which are pale yellow or colourless when in faintly acid solution, but bright yellow in alkaline solution; and (2) the anthocyans, which are red in acid solution, violet when neutral, and varying from dull red or reddish-brown to purple and blue when present in the form of alkaline salts in solution. It would appear from chemical investigations that the anthocyan (anthocyanin) pigments are reduction products of the yellow sap pigment, whilst botanical work points to the conclusion that these anthocyan pigments are present in plant life in positions that are known as the seat of oxidizing influences (oxydases): hence the hypothetical conception that pigmentation results from the action of oxydases on chromogens of colourless character.

The anthocyanins are glucosides of three parent anthocyanidins (or their methyl ethers) named pelargonidin, cyanidin, and delphinidin, whose hydrochlorides are formulated as $C_{15}H_{11}O_5Cl$, $C_{15}H_{11}O_6Cl$, and $C_{15}H_{11}O_7Cl$. (See Delphinine.) In the formation of flower pigments, these glucosides are hydrolysed by enzymes of the emulsin type; the free chromogen is then oxidized by atmospheric oxygen activated by oxydases, and either dextrose, rhamnose, or galactose is formed, dextrose being the principal sugar. Pelargonidin, cyanidin, and a number of other allied substances have been synthesized.

Xanthophyll and fucoxanthin are represented by the formulæ $C_{40}H_{56}O_2$ and $C_{40}H_{54}O_6$ respectively.

According to Karrer and Saloman, a xanthophyll $C_{40}H_{56}O_2$ of m.p.

PLANT COLOURING MATTERS (*Continued*)—

175° to 176° C. can be extracted, together with sterols and other substances, from dandelion flowers (*Taraxacum officinale*).

The green colouring matter, chlorophyll, present in the cells (chloroplasts) of the leaves and other parts of plants is only developed (so it has been alleged) when sulphur is present and when growth takes place in the light. It is extractable from the leaves by acetone, while other solvents appear to separate it into two parts, which differ in their spectra and are known as A, which is described as a blue-black powder formulated as $Mg.C_{55}H_{72}N_4O_5$, and B, a dark green powder formulated as $Mg.C_{55}H_{70}N_4O_6$. It has been conjectured that some relationship or correspondence exists between these several substances and the colouring matter of blood, as two of the pyrrole rings out of the three obtained from the reduction of chlorophyll are also obtained from hæmoglobin.

Fresh leaves are stated to contain about 2 grams of chlorophyll per kilo, and a body named phytol, which has been synthesized and appears to be built up of reduced units of isoprene, is an important item in its structure.

Chlorophyll is soluble in certain oils, alcohol, and ether, and is associated in the colouring materials of plants with carotene and xanthophyll, which is regarded as an oxidation product of carotene. Xanthophyll is soluble in ether at 25° C. to the extent of 952 m.g. per litre and oxidizes readily in that solution, but is stated to keep well in alcohol. Chlorophyll is supposed to constitute the photocatalytic agent by means of which carbohydrates are formed in plants through the intermediate production of formaldehyde from carbon dioxide and water, the polymerization of that product into a kind of sugar, and (by the loss of water and condensation) the transformation of that sugar molecule into carbohydrates of the general formula $(C_6H_{10}O_5)_n$.

According to K. Noack, the magnesium of proto-chlorophyll can be removed by acid, and the resulting product is a red dye (*B.C.A.*, 1929, A, 476). (See also *B.C.A.*, 1928, A, 1382-1385, for other references to chlorophyll by H. Fischer and others.)

Respecting the commercial applications of chlorophyll, see *C.T.J.*, 1927, **81**, 405, and *Ind. Eng. Chem.*, October, 1927.

The mosaic variations often observed in the foliage or flowers of plants has been attributed to infections of filter-pass nature. (See Bacteria.)

Carotene (**Carotin**) is a hydrocarbon of the composition $C_{40}H_{56}$, which crystallizes in copper-coloured leaflets, absorbs oxygen readily from the air, and becomes converted into a colourless product. The solubility of carotene in absolute alcohol is stated to be 15·5 mg. per litre, and in anhydrous ether 1,005 mg. per litre, while 50 lbs. of fresh carrots are said to yield 1·13 grm. pure carotene of m.p. 174°. Submitted to five successive purifications, it is stated to have a m.p. 184° to 185° C. and to retain its vitamin activity (Javillier and Emerique, *B.C.A.*, 1930, A, 1221). It has recently been found to confer immunity in growing rats against certain diseases which occur in them when vitamin

PLANT COLOURING MATTERS (*Continued*)—

A is absent from their diet, hence the value of carrots, green vegetables, etc., would seem to depend upon the presence in them of carotene, bearing in mind the value of these vegetables, together with eggs and butter, as sources of vitamin A. If carotene exercises a similar function in man, it should prove to be a valuable prophylactic and therapeutic agent, and vegetable soups in particular should constitute an important part of food. (See Hume and Maclean, *Lancet*, 1930, i., 290-292); N. S. Capper (*Biochem. J.*, 1930, **24,** 980); N. Bezssonoff (*B.C.A.*, 1930, A, 505), Drummond, Ahmad, and Morton on "The Relation of Carotene to Vitamin A" (*J.S.C.I.*, 1930, **49,** 292 T); J. M. Gulland (*Chem. and Ind.*, 1930, **49,** 839); and Olcott and McCann (*J. Biol. Chem.*, 1931, **94,** 185).) It is stated to be isomeric with another colouring matter named lycopin, and xanthophyll with rhodoxanthin. The carotinoids, as these colours are termed, range from yellow to red, and although possessed of very similar physical properties, differ chemically as shown.

Karrer and Helfenstein (*B.C.A.*, 1930, A, 76) propose another formula and state that oxidation of a benzene solution of carotene affords a substance probably identical with ionine. (See also R. Kuhn (with others), *B.C.A.*, 1931, A, 1421.)

The anthocyans (anthocyanins) are said to contain similar nuclei, no matter how much they differ in colour, and the wide variation of tints is ascribed to slight differences in constitution which leave the main skeleton intact. Yeast decomposes anthocyans with loss of sugar.

The colouring matter of the scarlet pelargonium known as "Scarlet Meteor" (*Pelargonium zonale*), and another variety, known as "James Kelway," occurs in the petals to the extent of 6·6 to 7·1 per cent. of the dry weight as an oxonium salt of the diglucoside of pelargonidin—namely, pelargonin (probably pelargonin tartrate)—and was the first of the anthocyanin pigments obtained in crystalline form.

The anthocyanin of *Salvia coccinea* is named salvianin, and upon hydrolysis yields pelargonidin, dextrose, and malonic acid. That of the wallflower has been isolated, and the pigment of the polyanthus identified as a monoglucoside.

The red pigment of the young leaves of the grape-vine is said to be a free anthocyanidin, probably identical with œnidin, the anthocyanidin of the purple grape (*Vitus vinifera*), although it may appear in a colourless modification termed a *leuco-anthocyanin,* in which it appears to be associated with another substance, possibly a carbohydrate, giving rise to anthocyanidin on treatment with strong acids. (See R. J. Anderson and F. P. Nabenhauer on "Grape Pigments" (*B.C.A.*, 1927, A, 61).) The same colouring matter occurs in the cactus, dahlia, and the pink cornflower, whereas blue cornflowers contain cyanin in potassium salt form.

According to Anderson and Nabenhauer, the pigment in Clinton grapes (*Vitis riparia*) consists of a monoglucoside anthocyanin identical with that of the Norton and Concord grapes, the chloride ($C_{23}H_{25}O_{12}Cl$) yielding by hydrolysis with hydrochloric acid, one molecule each of

PLANT COLOURING MATTERS (*Continued*)—

glucose and anthocyanidin ($C_{17}H_{15}O_7Cl$) of crystalline form, and having the same percentage and composition as œnidin chloride, but differing from it in that it contains a lower percentage of methoxyl. (See *J. Biol. Chem.*, 1924, lxi., 97-107.)

A red pigment known as "carajura" or "chica," prepared by Indians in Central America from a species of bush-rope, has been found by A. G. Perkin to contain a red crystalline substance named carajurin, having an anthocyanidin nucleus. The blue cornflower yields a pigment identical with that of the red rose, named cyanin, which gives a chloride of the composition $C_{27}H_{31}O_{16}Cl$, and upon heating this substance with a 20 per cent. solution of hydrochloric acid, it is hydrolysed into cyanidin and glucose:

$$C_{27}H_{31}O_{16}Cl + 2H_2O = C_{15}H_{11}O_6Cl + 2C_6H_{12}O_6.$$

The petals of the deep red rose "George Dickson" are stated to contain 10 per cent. of the anthocyan pigment cyanin, and the peel of the rosy apple is tinted with a pigment of the same class as that of the garden radish.

The cyanin dyes belong to a group of bases known as the benthothiazole series, which bear a marked relation to quinoline (C_9H_7N) and quinaldine ($C_9H_6N.CH_3$).

The archil or cudbear group of colours and many of the yellow sap pigments were largely used in the past as dyes before the synthetic colours became available in industry, and some of them, such as *fustic*, are still employed.

Other references: R. Robinson on "The Structural Relationship of Some Plant Products" (*Chem. and Ind.*, 1925, **44**, 1182) and on the Synthesis of Anthocyanins (*Chem. and Ind.*, 1931, **50**, 46, and *Ibid.*, 1932, **51**, 208); I. T. Kataoka on "The Anthocyanin Pigments of 'Morning Glory'" (*B.C.A.*, 1926, p. 1150); "Some Experiments on the Synthesis of Anthocyanins," by A. Robertson and R. Robinson (*J.C.S.*, 1926, p. 1713, and 1927, pp. 242 and 1710); Meunier and Bonnet (*J.C.S. Abs.*, 1925, I., 1439); Karrer and Widmer on "Vegetable Colouring Matters" (*B.C.A.*, 1927, A, 252, 253, and 571; *Chem. and Ind.*, 1929, **48**, 724; 1928, pp. 1526-1532 and 1541); Robinson and Venkataraman (*J.C.S.*, 1929, p. 61); Karrer (with others) (*B.C.A.*, 1929, A, 74; *Ibid.*, 1930, A, 333 and 1422); Lovecy, Robinson, and Sugasawa (*J.C.S.*, 1930, p. 817); Robinson and Schwarzenbach (*Ibid.*, 1930, p. 822); R. Robinson (with others) (*J.C.S.*, 1931, pp. 2665-2738); R. Robinson and Mrs. G. M. Robinson on "Constitution of Anthocyanins" (*Nature*, 1931, **128**, 413); G. M. Robinson and R. Robinson on "Survey of Anthocyanins" (*Biochem. J.*, 1931, **3**, 99); R. Scott-Moncrieff (*Biochem. J.*, 1930, pp. 24, 753-766, 767-768, or *B.C.A.*, 1930, A, 967); Archil, Alizarine, Carotinoids, Chlorophyll, Cudbear, Flavone, Morin, Photo-catalysis, and Vegetation.)

PLANT CUTICLES—See Legg and Wheeler (*J.C.S.*, cxxvii., 1412).

PLANT LIFE—See Fertilizers, Nitrification, Plant Colouring Matters, Soils, and Vegetation.

"PLASMON"—A proprietary preparation of milk casein made soluble by agency of alkalies.

PLASTER OF PARIS—See p. 123 and *C.T.J.*, 1927, **81,** 63.

"PLASTEX"—One of the "permitted explosives" which may be used in certain classes of mines.

PLASTIC WOOD—See *Ind. Chem.*, 1932, viii., 33; "Necol" and Xylolith.

PLASTICITY—See Plastometer.

PLASTICIZERS (and Softeners) are used in making lacquers in order to prevent brittleness in the films. They include triacetin (which is one of the best), amyl tartrate, di-ethyl phthalate, di-butyl phthalate and tartrate, castor oil, aromatic esters, etc. Amylene dichloride is used as a plasticizer in the rubber industry. Some details respecting them and their applications are given by Scott, Bader and Co., Ltd. (*Ind. Chem.*, 1929, v., 494). Their uses in "Cellulose Paints and Lacquers" is the subject of an article by T. H. Durrans (*C.T.J.*, 1927, **80,** 251); see also references by H. S. Garlick (*Chem. and Ind.*, 1927, **46,** 336); *C.T.J.*, 1928, **82,** 147; H. Messer (*J.S.C.I.*, 1931, **50,** 386 T); Casein, Lacquers, and Pyroxylin.

PLASTICS—See E. C. Bingham (*J.S.C.I.*, 1931, **50,** 419 T); Casein, Gums and Resins (Synthetic), Plasticizers, and *British Plastics Year Book*, 1932 (Plastics Press, Ltd., London).

PLASTOMETER—A variety of viscometer for the determination of viscosity and plasticity. A simple form is described in the *Ind. Chem.*, 1925, i., 506. An instrument for measuring the plastic properties of clay is described by J. D. Davis (*Ind. Eng. Chem.* (*Anal.*), 1931, **3,** 43). (See also Gregory (with others) on a modified form (*B.C.A.*, 1930, B, 589); and Viscosity.)

PLATINAMMINES—Chemical compounds, many of which are of complicated structure, including tetrammine platinous chloride ($Pt(NH_3)_4Cl$). (See also Ammines and Platinum Bases.)

"PLATINITE"—An alloy of nickel and iron (46 per cent. nickel) having approximately the same coefficient of expansion as glass, used instead of platinum for certain work in glassware—as, for example, electric incandescent lamps. It is frequently covered with a thin coating of copper, to which the glass adheres, and is then called "red platinum."

"PLATINOID"—The name of an alloy of German-silver character containing from 1 to 2 per cent. of tungsten.

PLATINUM (Pt) **and its Compounds**—Atomic weight, 195·2; sp. gr., 21·5; m.p., 1,771° ± 2° C. The m.p. has been recently re-determined by Ribaud and Mohr as 1,762 ± 2° for platinum of purity 99·99 per cent. (*B.C.A.*, 1931, A, 189). Platinum is found naturally in the metallic state in small grains and nuggets in river sand and alluvial deposits in Brazil, Borneo, California, Colombia, New South Wales, Sardinia, Mariah Island, Tasmania, the Waterburg and Lydenburg districts of

PLATINUM (*Continued*)—

North-Eastern Transvaal, Island of Chiloe, Chile, and the Ural Mountains; also as *iridosmine, sperrylite,* etc., in association with some other rare metals, including palladium, rhodium, ruthenium, osmium, and iridium. Some nickel-copper-cobalt deposits at Shebandowan Lake, North Ontario, are rich in platinum. (See Sperrylite.) Up to 1914 Russia supplied over 90 per cent. of the world's output, estimated at under 300,000 ozs. in 1913, 80,000 ozs. in 1924, and (later) 100,000 ozs., while Colombia produces about 45,000 ozs. annually. The statement is made that of 400,000 ozs. of the so-named platinum metals, approximately 300,000 will be produced in England from the Canadian nickel-copper ores found in the Sudbury district of Ontario (see *Ind. Chem.*, 1931, vii., 207). A flotation process is used to remove the black sand accompanying the platinum in the concentrates.

Platinum is of a bright greyish-white colour, malleable and ductile, does not tarnish in the air, is heavier than gold, and of low electric conductivity. On account of its soft character it is usually alloyed with a small percentage of iridium to make articles of commercial service.

To obtain platinum from associated metals, it is digested in *aqua regia* under some pressure, the solution evaporated to dryness, and the residue heated to 125° C. Any rhodium chloride is thus rendered insoluble, and upon extraction with water, acidification of the extract with hydrochloric acid, and addition of ammonium chloride, the red double ammonium and platinum chloride or ammonium chloroplatinate ($2NH_4Cl,PtCl_4$) is produced and crystallized out (the corresponding iridium salt, so far as it is present, being left in the mother-liquor), and from this, spongy platinum is obtained upon ignition, and may be hammered into a concrete mass or melted in the oxyhydrogen flame.

"Spongy platinum" is obtained by igniting the ammonium-platinum chloride above described; while "platinum black" is a soft black powder which results from the precipitation of platinum solutions by means of reducing agents. In both of these forms the metal exhibits the property of condensing gases on its surface in a high degree, and a mere fragment of the spongy metal, when introduced into a mixture of hydrogen and oxygen gases in the proper proportions, at once causes an explosion with formation of water. Even when cold, platinum has the property of condensing oxygen on its surface, and in the forms already described, and in that of gauze, the metal is used as a catalyst—for example, in the oxidation of ammonia to nitrogen oxides and nitric acid. This catalytic action is easily interfered with by traces of many substances, phosphine being one of such "poisons," as they are termed. (See S. W. Pennycuick (*J.C.S.*, 1927, p. 2600); S. H. Bastow on "Absorption of Nitrogen by Atomic Platinum" (*J.C.S.*, 1931, p. 1950); Sieverts and Brüning on "Occlusion of Hydrogen by Platinum-Black" (*B.C.A.*, 1932, A, 16 and 33); and Catalysis (p. 153).)

Platinum forms alloys with many metals, and the introduction of 10 per cent. iridium produces a combination which is even more resistant to chemical action than the pure metal.

There are two oxides (insoluble in water)—viz., the platinous and

PLATINUM (*Continued*)—

the platinic (PtO and PtO_2), both blackish powders, and corresponding hydroxides ($Pt(HO)_2$ and $Pt(HO)_4$), the latter of which, when dried and heated sufficiently, is decomposed, leaving the metal in the free state.

There are two chlorides (viz., $PtCl_2$ and $PtCl_4$), the first of which is a green powder insoluble in water, whilst the latter (obtained by dissolving platinum in aqua regia) is a yellowish-red crystalline salt soluble in water and alcohol. The former compound is used to some extent in the platinotype photographic process. It forms double salts with some other chlorides—for example, the platinum-potassium compound described as potassium chloro-platinate ($2KCl,PtCl_2$ or K_2PtCl_4) (a red salt soluble in water and used in photography), and the ammonium chloro-platinite ($2NH_4Cl,PtCl_2$).

Platinic chloride ($PtCl_4$) similarly forms double salts: the potassium compound ($2KCl,PtCl_4$ or K_2PtCl_6) being a yellow crystalline body only slightly soluble in cold water, and which is decomposed upon heating into potassium chloride, chlorine, and free platinum; the ammonium compound ($2NH_4Cl,PtCl_4$), which is still less soluble in cold water, and when similarly exposed, is reduced to pure platinum; and the sodium salt ($2NaCl,PtCl_4$), which is reddish-yellow and readily soluble in water.

Chloro-platinic acid (H_2PtCl_6,H_2O), prepared by the action of aqua regia on the metal, followed by evaporation of the solution and crystallization, is a red-brown crystalline substance, soluble in water and alcohol, used in electro-plating, preparing platinized catalysts, and making indelible ink.

Two sulphides (PtS and PtS_2) are known, both of which are black and insoluble in water.

The cyanide ($Pt(CN)_2$) combines with other cyanides to form double compounds known as platino-cyanides—for example, potassium platinocyanide ($2KCN,Pt(CN)_2$).

There are a series of platinammonium compounds or platinum bases similar to the cobalt-ammines, one group being derived from the chloride $PtCl_4$ and another from $PtCl_2$. These compounds are regarded as containing certain molecules of ammonia co-ordinated with the metal. One compound, having the composition $Pt(NH_3)_2Cl_2$, is known as *the green salt of magnus*, and another has the composition $[Pt(NH_3)_4]Cl$.

The jewellery trade is the predominant factor in the platinum market, while in chemical industry it is used for making stills for the concentration of sulphuric acid, also in the electro-chemical industry, while its uses as a catalyst have already been referred to. An alloy used by jewellers consists of 1 part platinum, 1 part copper, and 2 to 5 parts silver.

"Platinor" consists of 2 parts platinum, 5 parts copper, 1 part silver, and 1 part nickel.

One form of so-called "mockgold" consists of 7 parts platinum and 16 parts copper.

Platinum bronze is made of 1 part platinum, 90 parts nickel, and

PLATINUM (*Continued*)—

9 parts tin; whilst a variety of dentist's alloy is made of 5 parts platinum, 3 parts gold, and 4 parts palladium.

In the forms of crucibles, dishes, foil, spatulas, weights, wire, etc., platinum is largely used in laboratories on account of its refractory nature—that is, its capability of withstanding exposure to a high degree of heat and attack by many chemicals—although it is attacked at a red heat by alkalies, nitrates, cyanides, phosphorus, arsenic, etc.

In the form of foil, as held by a pair of tongs in the hands, it is useful for testing the action of heat upon chemical substances placed on its surface, the foil being placed directly over the flame of a spirit-lamp or Bunsen burner. It can thus be ascertained whether they fuse or char (indicating the presence of organic matter), or are volatile, or give off a distinctive smoke or odour; and if they burn, whether they do so with any notable feature or communicate any particular colour to the flame to which they may be exposed, etc.

Care has to be taken that it is not exposed to the action of other molten metals such as lead, as the two metals will form an alloy if exposed to a sufficiently high temperature, and result in the ruin of the platinum, which is a very costly metal. It can only be dissolved by nitrohydrochloric acid (*aqua regia*).

Platinum Crucibles are most useful for exposing substances to heat with the view of burning off volatile or organic constituents, or of fusing refractory substances with added chemicals (fluxes) in order to obtain them in a form soluble in some menstruum.

Platinum Dishes are utilized for evaporation of solutions which are likely to attack glass or porcelain.

Platinum Weights of small size are valuable because the metal does not tarnish in the air, and the weights are not easily corroded by accidental contact with chemicals as are copper and brass weights; 0·5 gramme, 0·2 gramme, 0·1 gramme, and some smaller ones, are among those frequently employed.

Platinum Wire is useful for stirring liquids which attack glass rods, and for exposing liquids or solids spread over its surface to the flame of a Bunsen burner, in order to tone the distinctive features attendant thereon. For this application the wire is bent into a loop at one end, so that a bead of the liquid or solid to be tested may be held thereon, the other end of the wire being held by tongs, or fixed in a wooden handle, or fused into a glass tube. (See Boron (Borax).)

Platinum Metal—See Donald McDonald (*Chem. and Ind.*, 1931, **50**, 1031-1041); and **Recovery** (*C.T.J.*, on the Metal Recovery, 1931, **88**, 430).

Platinum (**Colloidal**) is the subject of papers by S. W. Pennycuick (*J.C.S.*, 1929, p. 618, and 1930, p. 1447).

PLATINUM BASES (**Organic**)—Combination of salts of the amines, such as the chlorides, with platinic chloride—for example, methylamine

PLATINUM BASES (*Continued*)—
platini-chloride $(CH_3NH_3)_2PtCl_6$. (See Ammines and Platinum Compounds (p. 716).)

PLAUSON'S COLLOID MILL—It is reported that this mill only reaches its maximum efficiency at higher speeds than 3,000 revolutions, which is the maximum available using an electric motor, but may be run up to as much as 12,000 revolutions using, for example, a steam turbine. It is an improvement on the ordinary druggist's "Perplex" beater mill for grinding rubber, ultramarine, litharge, magnesia, graphite, zinc oxide, kaolin, and other materials to a very fine state of division (0·001 to 0·00001 mm.), showing the characteristic Brownian movement. Other substances acting as protective colloids may be added, such as tannin in graphite grinding, soap solution with talc, glycerine with sulphur, etc., and the mill may possibly be of great service in preparing colloidal or liquid coal. (See Colloidal Fuel.)

By reason of the extreme state of division to which it can reduce solid particles, it is said to destroy bacilli which are of larger size. It can be used for preparing emulsions of essential oils and esters with water, thus obviating the use of alcohol, ether, etc.; in the preparation of perfumes, etc.; for preparing emulsions of mineral oil and coal-tar oils with water intended for lubricating, the more so on account of their cooling properties and being devoid of chemical attack; further, for the preparation of viscose by avoiding the use of the large excess of caustic soda ordinarily necessary. In this last-named application, by using the theoretical amount only of soda, a colloidal solution of sodium-cellulose is produced, which readily yields sodium-cellulose-xanthogenate when treated with carbon disulphide.

It is also supposed to be applicable to the direct treatment of wood sawdust without first of all preparing cellulose from it. The "Oderberg" design is reported to be an improved form of this apparatus. Some criticism has been made in respect of the efficiency and economy of this and other colloid mills. (See F. Hebler, *B.C.A.*, 1928, B, 877); Grinding and Premier Mill.)

PLESSY'S GREEN—See Chromium (Phosphate).

"PLOMBIT"—A new German acid-resisting material of m.p. 130° C., said to be a combination of hard rubber and oleic acid with strong sulphuric acid and sulphur.

PLUMBAGO—Another name for graphite or black-lead. (See Carbon.)

PLUMBATES—See Lead (Dioxide), p. 527.

PNEUMATIC TRANSPORT PLANTS—See Chemical Plant.

PNEUMATIC TROUGH—An apparatus for the collection of gases over water (so far as they are insoluble in that medium), while in some other cases mercury is employed. In the former case it consists of a vessel of glass or tinplate provided with a shelf situate at one end at a depth of 2 or 3 inches from the top. The vessel for collecting the gas is filled with liquid and placed mouth downwards over a funnelled hole provided in the shelf, underneath which the delivery tube conveying the gas from the generator is placed, the bubbles of gas passing up and

PNEUMATIC TROUGH (*Continued*)—
displacing the liquid contents of the collecting vessel. When mercury has to be employed, the trough is made of stoneware, glass, or porcelain. (See Gas Generators.)

PODOPHYLLIN—A resin extracted by rectified spirit from the rhizome or roots of *Podophyllum peltatum,* N.O. Ranunculaceæ, indigenous in Canada and some parts of N. America; soluble in alcohol and ether, and used in medicine as an anthelmintic, emetic, and purgative. Another (Indian) variety from *Podophyllum emodi* is a native of the Himalayas and yields the highest proportion of resin. (See Wallis and Goldberg, *Analyst,* 1931, **56,** 468.)

"POILITE"—A material made from asbestos and cement in the form of sheets, roof-tiles, etc.

POISON GASES—The toxicity of gases and fumes in parts per 10,000 of air is given (with some reservation) in a table by Sir Thomas Legge in his lecture (Inst. Chemistry, February 21, 1930) on "Lessons Learnt from Industrial Gases and Fumes." (See Gassing.)

POISONS AND ANTIDOTES—Among other antidotes against poisons may be noted:

Acids	Magnesia, lime, or chalk made into a milk with water.
Aconite	Stomach-pump or emetic.
Alkalies	Emetic, followed by dilute vinegar.
Antimony	Emetic, decoction of bark or strong tea, and keep warm.
Arsenic	Emetic, followed by freshly precipitated ferrous oxide, or white-of-egg beaten up in milk, or magnesia.
Benzene	Emetic, fresh air, and artificial respiration when necessary.
Petroleum	
Paraffin	
Chlorine	Magnesia. (See also Gassing.)
Chloral	Emetic, keep awake, and artificial respiration when necessary.
Chloroform	
Carbolic acid	Olive oil, emetic or stomach-pump, followed by stimulants.
Carbon disulphide	Stomach-pump, warmth, stimulants, and artificial respiration.
Carbon monoxide	Inhalation of oxygen and artificial respiration. (See R. C. Frederick and report of discussion on this poisoning (*Analyst,* 1931, **56,** 562-572); also Coffee.)
Carbon tetrachloride	Strong tea or coffee, and such cardiac stimulants as used in chloroform poisoning.
Copper	Encourage vomiting, then give eggs beaten up in milk.
Corrosive sublimate	
Lead salts	Sodium sulphate or magnesia.

POISONS AND ANTIDOTES (*Continued*)—

Laudanum	Emetic or stomach-pump, or purified charcoal-powder if swallowed immediately after the poisoning, and keep patient well awake.
Morphia	
Opium	
Nitrous gas	Early use of ammonia.
Oxalic acid	Chalk and water freely.

One of the best emetics is mustard—half a tablespoonful mixed in half a tumbler of water—and for children one or two teaspoonfuls of ipecacuanha wine every ten minutes. Another good emetic for adults is a teaspoonful of sulphate of alumina.

Lead dust present to a less extent than 5 milligrammes per 10 cubic metres is alleged to be comparatively innocuous, and 2 milligrammes is the daily dose that a worker can absorb and escape chronic poisoning.

It has been found that 20 parts of benzol per 10,000 parts air is on the border-line of poisoning.

It appears from recent investigations that poisoning from tinned meat is not caused by putrefactible bacilli or their products, but is due to the presence of some specific and highly toxic bacillus, such as Gaertner's bacillus.

In a lecture by H. Wilson Hake, given at Westminster Hospital on September 30, 1924, attention was directed to the fact that in the period of twenty years ending 1904 there were 14,275 deaths by poison, and of those used in cases of suicide over 2,000 were due to carbolic acid, over 1,200 to opium, over 900 to oxalic acid, over 800 to prussic acid, over 500 to hydrochloric acid, over 300 to strychnine, and nearly 200 to phosphorus; while in the period 1914-1923 the deaths from poisoning numbered 9,733. Among the poisons responsible for some of these cases must be listed corrosive sublimate, coal gas, sulphuric acid, arsenic, nitric acid, ammonia, vermin-killers, chloral hydrate, belladonna, aconitine, hyoscine, phosphine, and tartar emetic. (See J. Barger on "Poisons of Animal Origin" (*J.S.C.I.*, 1917, p. 32 T); address by Sir W. Willcox (Institute of Chemistry, January, 1925); "Report of Lecture," by W. F. Boos (*C.T.J.*, 1925, **77,** 713); "The Pathology of Some Industrial Poisons," by A. J. Amor (*Chem. and Ind.*, 1931, **50,** 475); A. Wynter Blyth and M. Wynter Blyth on *Poisons* (Charles Griffin and Co., Ltd., London); and *Chemical Warfare* (Williams and Norgate, Ltd., London).

For further information concerning chemical poisoning and industrial diseases, readers are referred to the Annual Reports of the Chief Inspector of Factories and Workshops. (See also Bacteria, Food Poisoning, Gassing, Safety Measures, and Toxicology.)

POLARISCOPE (Polarimeter)—See Light, p. 536.

POLARITY—See Electricity, p. 292.

POLARIZATION—See Light, p. 536.

POLENSKI VALUE—See Fats, p. 338.

"POLLOPAS"—A new glass-like synthetic resin of Austrian make, being a condensation product of carbamide (urea) and formaldehyde. It is

"POLLOPAS" (*Continued*)—
colourless, transparent, of sp. gr. 1·44, having a dispersive power almost identical with that of rock-crystal, so that it can be used in mirrors, lenses, etc. It can be easily turned, is resistant to alcohol and water, constituting a useful commercial commodity for making lacquers, buttons, umbrella handles, etc., although it chars at 200° C. Its refractive index lies between 1·54 and 1·9 (about the same as flint glass); it has a hardness of about 2·95 on the Mohr scale, and does not absorb the ultra-violet rays normally withheld by glass. (See *C.T.J.*, 1924, **75**, 269, and 1926, **79**, 618.)

POLLUX (**Pollucite**)—A complex silicate containing cæsium, occurring in *pegmatite*, found in Maine, etc.; crystal system, No. 1, and sp. gr. 2·86.

POLONIUM (Po)—A radio-active substance obtained from pitch-blende, said to be a degradation product of radium, and now described as an element of atomic number 84; stated to form a sulphide analogous to that of bismuth.

POLYBASITE—A mineral compound—sulphide of silver and antimony (other metals being associated), found in some of the U.S.A. and elsewhere (crystal system, No. 4, and sp. gr. 6·2).

POLYMERISM—A form of isomerism. A character of substances having the same percentage composition, but distinct in properties and differing in formulæ (mass), as evidenced by determination of their molecular weights: aldehyde (C_2H_4O), for instance, slowly changes into paraldehyde ($C_6H_{12}O_3$), the last named being the *polymer* or *polymeride* and its molecular weight is a multiple of that of its originating compound. (See Isomerism.)

POLYMORPHISM—Existence of a substance in various crystalline forms.

POLYPEPTIDES—Hydrolysed derivatives of proteins resembling peptones in some respects, in which two or more so-called amino-acid groups are combined—the carboxyl group of one acid condensed with the amino group of another. (See Abderhalden and Heumann (*B.C.A.*, 1930, A, 1420), and Abderhalden and Brockman (*B.C.A.*, 1930, A, 1603), who describe a process by means of which polypeptides may be broken down step by step into their constituent amino-acids; also Albumins, Enzymes, and Proteins.)

POLYSACCHAROSES—See Carbohydrates.

PONTIANIC (**PONTIANIK**) **RESIN**—See Gums and Resins, p. 427.

POPPY SEED OIL is expressed from the seeds of the black or opium poppy (*Papaver somniferum*, var. *nigrum*), which yield about 36 to 40 per cent. It is odourless, soluble in ether, chloroform, and carbon disulphide, solidifies at − 18° C., and is one of the drying class of oils. It resembles olive oil in appearance, and contains about 8 per cent. of solid fatty acids, 30 per cent. oleic acid, 60 per cent. linoleic acid, and 5 per cent. linolenic acid. Its sp. gr. is 0·9249, sap. v. 193 to 195, i.v. 133 to 143, and ref. ind. 1·457. It is used as food in some parts of Germany and France, and for mixing with light colours for use in

POPPY SEED OIL (*Continued*)—

painting, after being bleached in the sun; also in soap-making, for adulterating olive oil, and in varnish-making. (See Argemone Oil.)

POPULIN (or **Benzoyl Salicin**) ($C_{10}H_{22}O_8$)—A soluble glucoside contained in the bark, leaves, and root of the aspen (*Populus tremula*), and which can be artificially made from benzoyl chloride ($C_6H_5.CO.Cl$), and salicin ($C_{13}H_{18}O_7$). It yields salicin and benzoic acid upon hydrolysis.

PORCELAIN AND EARTHENWARE articles are made largely of clay coated or glazed with some substance that fuses at a high temperature, thus giving them a coating and at the same time binding the body of the material together in coherent mass. The normal (triaxial) porcelain mixture may be said to consist of 50 per cent. clay, 25 per cent. quartz, and 25 per cent. felspar. The best quality of china clay or kaolin (aluminium silicate) is used for porcelain goods (which are fired at the highest temperature and are vitreous in structure) and the poorer qualities of clay for earthenware articles, the glaze for the former being felspar alone or mixed with quartz and lime in finely powdered form suspended in water, into which mixture they are dipped or coated by brushing before firing. In making "spode china" bone phosphate is used, and gives the best quality of porcelain in respect of durability. Earthenware bodies contain as a rule about 70 per cent. silica, the materials used being ball clay, china clay, and flint. A published analysis of a superior English product shows a content of 66·17 per cent. silica, 29·40 per cent. alumina, and small proportions of ferric oxide, phosphoric acid, lime, magnesia, soda, and potash.

"Cornish stone" (derived from *pegmatite*) consists of approximately equal parts of felspar, quartz, and clay, and is therefore a ready-made material. The high-fire glazes vary in composition according to the articles to be treated, those for chemical porcelain consisting of varying proportions of silica and alumina, together with certain proportions of lime and potash. For earthenware goods, a "salt glaze" is used and applied by introducing salt into the furnace containing the ware, in which it is volatilized and decomposed by the heated surfaces of the articles, causing the formation of a fusible double silicate of sodium and aluminium on their surfaces.

Small articles are built up on the potter's wheel, but larger ones are more readily made by building up with plastic clay or by the use of "slip" (a mobile suspension of clay in water made by deflocculating clay with alkali or sodium silicate), followed by casting in plaster moulds. The characters of "slip" form the subject of an article by F. Grove-Palmer (*Chem. and Ind.*, 1929, **48,** 190).

Articles of stoneware, such as jars and drain-pipes, are fired at a high heat and salt glazed, while for many varieties of earthenware, which are fired at a comparatively low heat, easily fused glazes containing lead or borax are used. The use of lead compounds is viewed with growing disfavour by reason of their poisonous effects in pottery works. Lead silicate containing about 65 per cent. lead oxide combined with 35 per cent. silica is now being used largely as a glaze in

PORCELAIN (*Continued*)—

pottery work, having a solubility of less than 5 per cent. when determined by the Thorpe solubility test under the Lead Regulations. For fine qualities of ware, such as Delft and Majolica, the surfaces are coated with opaque white glaze containing stannic oxide (SnO_2).

The white-glazed sanitary fire-clay goods are a refined class of stoneware made from clays of very similar colour and character, but more refractory to heat at a kiln temperature of about 1,250° C. The colour is obtained by introducing an intermediate layer of white substance between the clay and the finishing glaze, muffle kilns being used to maintain an oxidizing atmosphere and to exclude dust. The process is described in detail by W. Thomason (*Ind. Chem.,* 1925, i., 91).

The preparation of varieties of yellow and blue Celadon glazes is referred to in two abstracts by T. Ishii (*B.C.A.*, 1930, B, 1066).

The clays used in making porcelain and earthenware lose their chemically associated water when heated to from 480° to 600° C., while the temperature used in making non-absorbent or vitreous porcelain ranges from 1,250° to 1,550° C., and that for porous or non-vitreous ware from 1,150° to 1,250° C. Hard porcelain melts at about 1,680° C., although it becomes soft below that temperature, so that unglazed porcelain can be used only up to 1,400° C. and the glazed quality up to 1,200° C., but a new so-named "pythagoras mass" is more satisfactory and is suitable for the manufacture of pyrometer tubes and over a wide range of temperatures up to 1,700° to 1,750° C. (See *Chem. and Ind.,* 1929, **48,** 565 and 633.)

Chemical stoneware consists of a mass of refractory matter held together or cemented by vitrifying selected clays. On the one hand, coarse-grained chamotte bodies of fire-brick nature are used, as, for example, for conveying acid gases at high temperature; and, on the other hand, fine-grained porcelain bodies, as required for large storage-battery tanks used for electrical purposes, with an infinite number of varieties in between these two extremes, so that as no one clay meets all these requirements, it is often necessary to make mixtures of several kinds to obtain the desired qualities.

One published typical analysis of chemical stoneware is given as follows, and this resists all acids excepting such as act on silica—for example, hydrofluoric acid:

SiO_2	73·23	per cent.
Al_2O_3	22·27	,,
Fe_2O_3	0·58	,,
CaO	0·58	,,
K_2O	2·02	,,
Na_2O	1·42	,,
Loss on ignition	0·06	,,
	100·16	

There is now a British make of laboratory porcelain named "Sillax" of good quality.

Some qualities of ware, such as flower-pots, etc., are not glazed, and

PORCELAIN (*Continued*)—

this is true also of Spanish cooling vessels (alcarazzas), which are specially made porous in order to maintain a constant, slow evaporation and consequent cooling of the water contained in them.

Fracture in porcelain is not supposed to be wholly the result of crystallization, but that of attempted crystallization under stress—that is to say, to the possibility or otherwise of the adaptation of the matrix of the porcelain body of the crystals which develop in the heart of it. The use of steatite, china clay, kaolin, and felspar in the manufacture of highly efficient insulating products for the electrical industry is the subject of an article in *Chem. and Ind.*, 1930, **49,** 433. The behaviour of various felspars in vitreous bodies has been studied by Geller and Creamer (*B.C.A.*, 1931, B, 349), who show that the refractoriness increases and the softening range decreases with increase of K_2O. "The Constitution of Porcelain" is dealt with by Schwarz and Merck (*B.C.A.*, 1927, B, 43); see also note on "Recent Researches on Porcelain" (*Ind. Chem.*, 1926, ii., 184); "Porcelain Manufacture, with Special Reference to the Electro-technical Product" (*C.T.J.*, 1932, **90,** 227 and 252); "Relationship between the Constitution and the Properties of Porcelain," by R. Rieke (*B.C.A.*, 1926, B, 541); E. Schramm on "Sand-blast Test for Glazes" (*B.C.A.*, 1929, B, 326); and *Ceramic Industry*, by H. H. Stephenson (Davis Bros., 265, Strand, London); Clays, Refractories, Saggars, Shales, "Sillax," Sillimanite, Sinterkorund, and Steatite.

POROSITY—Possession of pores, interstices, or cavities—looseness of binding. Animal charcoal, pumice-stone, kieselgühr, spongy platinum, "tree-lead," and sponge are examples of porous articles. Many porous articles, particularly ordinary sponge, are absorbent and, in consequence, take up or hold in a mechanical sense large quantities of liquids, which can in some cases be squeezed out by pressure, thus consolidating the porous material. A new method for the determination of porosity has been described by P. B. Robinson (*J.S.C.I.*, 1926, **45,** 33 T), and a metal porosimeter for determining the pore volume of highly vitrified ware has been described by L. Navias (*B.C.A.*, 1926, B, 158).

The interstices between the atoms of compact solid and liquid bodies must be small, even if there are any interstices at all, so that porosity is often conspicuous by its absence—glass, for example, being highly impermeable to oxygen, nitrogen, and water. (See Diaphragms and Occlusion.)

PORPHYRITES—Crystalline igneous rocks. (See Rubidium.)

PORPHYRY—A form of felspar or felspathic base.

PORPOISE OIL—See Fish Oils, p. 353.

PORTLAND CEMENT—See Cement.

PORTLAND STONE—A granular oolitic limestone (calcium carbonate).

POTASH—See Potassium Compounds.

POTASH ALUM—See Aluminium (Alums), p. 39.

POTASH BULBS—See Organic Analyses, p. 647.

POTASSIUM (*Kalium*, K) **and its Compounds**—Atomic weight, 39·10; sp. gr. 0·861; m.p., 62·3° C.; b.p., 758° C.; credited with two isotopic forms. Potassium occurs abundantly in nature at Stassfurt, Germany, in the form of saline deposits of various compositions—viz., as chloride (KCl) in *sylvinite* (*sylvine*), as a double chloride of potassium and magnesium ($KCl.MgCl_26H_2O$) in *carnallite*, and as a compound sulphate and chloride ($K_2SO_4.MgSO_4.MgCl_26H_2O$) in *kainite*, the most popular potash manure.

There are somewhat similar and even richer deposits in Alsace, in the early strata of the Tertiary period (mostly pure *sylvinite, carnallite* being absent), estimated as sufficient for furnishing more than 300,000,000 tons of potassium oxide (K_2O). There are also large deposits at Catalonia, Kalusz (in the Carpathian region of Galician Poland), at Solikamsk in Russia, while in the Italian colony of Erythrea considerable deposits were found and worked during the Great War. The Alsatian sylvinite is a mineral mixture of potassium and sodium chlorides with some 9 to 14 per cent. insoluble matter (chiefly white clay and iron oxide), 0·5 to 1·2 per cent. water, 2 to 5 per cent. calcium sulphate, and a small proportion of magnesium chloride. After grinding, it is used as produced, or refined to a content of some 80 per cent. KCl.

It is estimated that the saline water of the Dead Sea contains, among other ingredients, 2,000 million metric tons of potassium chloride.

Nitrate and chloride of potassium are also found in association with sodium nitrate in the nitrate deposits of Chile and Peru, and in some of the Chinese provinces, while the "greensands," of which large deposits are found along the Atlantic sea-board, contain some 6 to 7 per cent. of potash said to be recoverable by digestion with slaked lime at 200° C.

Potassium compounds are found in the soil as products of decomposition of certain rocks (for instance, felspar), from which they find their way into vegetable life, and so into the bodies of the animals that feed upon it, thus accounting for the presence of potash in the *suint* or fat that is extracted from sheep's wool.

Potash can be recovered to some extent from the flue gases and dust of iron blast-furnaces. Blast-furnace gas contains from 4 to 6 grms. solid particles per cubic metre, yielding about 27 per cent. of potassium chloride. Common salt is introduced with the blast charge, and this, in reaction with the potassium contained in the iron ores, forms potassium chloride, which volatilizes and can be recovered from the fume and dust.

There is also a process for recovering it from molasses and by another as sulphate from the gases and dust carried over in the stack gases of cement works, about 2 to 7 lbs. being obtained per barrel of cement produced.

Potassium chloride is now chiefly obtained from *carnallite* and to some extent from *leucite* ($K_2O.Al_2O_3.4SiO_2$) (which in the pure state contains 21·5 per cent. potash, 23·5 per cent. alumina, and 55 per cent. silica, and is a constituent of the volcanic lavas which abound in Italy) by treatment with hydrochloric acid and further appropriate operations. By another process potash alum is obtained, using sulphuric acid for

POTASSIUM (*Continued*)—

dissolving the potassium and aluminium constituents of the crushed material. (See Leucite.)

The metal potassium is silver-white, lustrous, soft, and rapidly oxidizes in the air, its vapour taking fire, so that in the metallic state it has to be preserved in naphtha or kerosene.

It was formerly obtained by heating a mixture of potassium carbonate and carbon, the metal thus liberated distilling over and being collected in naphtha, but it was a difficult process and has been superseded by another in which fused potassium hydroxide is subjected to electrolysis, oxygen, hydrogen, and potassium being all set free. The potassium floats to the surface of the fused mass and is withdrawn from time to time under special precautions, whilst hydrogen gas is given off at the cathode and oxygen at the anode.

When potassium salts in aqueous solutions are electrolyzed, the metal set free reacts at once with the water and forms potassium hydroxide in solution, but if the concentration of the salt be increased to saturation, the hydroxide is decomposed by the current, and the reliberated metal may be collected by solution in mercury (R. Saxon, *C.T.J.*, 1925, **77**, 128).

By another process the metal is made from an amalgam at a temperature below 100° C. by using it as anode in an electrolytic cell, the electrolyte consisting of an inert salt of the alkali metal, such as potassium iodide dissolved in anhydrous ammonia. (See *C.T.J.*, 1924, **75**, 270.)

In common with sodium, it decomposes water, hydrogen being liberated.

Potassium Oxides—Potassium oxide (K_2O) can be obtained by the oxidation of potassium, as a grey crystalline body of sp. gr. 2·32, and when dissolved in water it forms a solution of potassium hydroxide (caustic potash):

$$K_2O + H_2O = 2KHO.$$

Two other oxides are known—viz., the dioxide (K_2O_2) and the tetroxide (K_2O_4)—but they are comparatively unimportant substances.

Potassium Chlorate ($KClO_3$) crystallizes in white tablets, is soluble in water to the extent of 3·3 per cent. at 0° C. and 59 per cent. at 100° C., and is largely used in the manufacture of explosives, percussion caps, matches, and pyrotechnics. It was originally made by the action of chlorine gas upon milk of lime and conversion of the calcium chlorate into the potassium compound by interaction with potassium chloride and crystallization from the liquid. It is now manufactured for the most part by the electrolysis of potassium chloride in a state of solution, the potassium hydroxide and chlorine generated in this way being allowed to mix at a temperature of 70° C., thus producing the chlorate, which can be obtained from the solution by evaporation and crystallization. A German process depends upon the electrolysis of caustic soda and use of chlorine with the aid of milk of lime and potassium chloride.

POTASSIUM (*Continued*)—

It melts at from 360° to 370° C., and below 400° C. begins to decompose into potassium perchlorate and oxygen gas:

$$8KClO_3 = 5KClO_4 + 3KCl + 2O_2.$$

By careful regulation of the temperature, however, the evolution of oxygen gas can be avoided, in which case the decomposition is represented as follows: $4KClO_3 = KCl + 3KClO_4$.

Potassium Perchlorate ($KClO_4$) can be prepared from the chlorate as shown above, also from its continued electrolysis. It is only slightly soluble in cold water, but at 100° C. 20 parts pass into solution. When heated to between 450° and 600° C. it decomposes as follows:

$$KClO_4 = KCl + 2O_2,$$

and the velocity of change is facilitated by the presence of a catalyst, such as ferric oxide.

Potassium Carbonate (K_2CO_3) was originally obtained from the ashes of wood—hence the name "pot ashes"—and is still extracted from this source in some parts of Canada and the U.S.A., where timber is abundant. A certain amount is made from the residue of beetroot molasses (see Molasses), but it is now chiefly made from potassium sulphate derived from the Stassfurt deposits by decomposition with calcium carbonate and carbon—resembling the old Leblanc soda process. It is soluble in water and used in the manufacture of soft soaps and glass, also for wool-washing. In the anhydrous form it is very deliquescent, and it forms a crystalline salt with water ($K_2CO_33H_2O$).

Potassium Bicarbonate ($KHCO_3$) is a less soluble potassium-hydrogen carbonate used in making baking-powders, and prepared by passing a current of carbon dioxide into a solution of the ordinary carbonate in water. There is also a process for making it by heating under pressure a mixture of barium carbonate and potassium sulphate in such proportions that a saturated solution of potassium bicarbonate results.

Potassium Cyanide (KCN) is a white, deliquescent, soluble crystalline salt of very poisonous character, largely used as a solvent of gold in certain methods of extracting that metal from its natural sources, and in electroplating. Among other methods, it is made of low grade by fusing potassium carbonate with sodium prussiate, while the higher grade is made synthetically by the "Beilby" process from potassium carbonate, charcoal, and ammonia. (See Cyanogen, p. 260; and Gold, p. 417.)

Caustic Potash (**Potassium Hydroxide**) (KHO) can be prepared by the action of slaked lime or milk of lime (CaH_2O_2) upon potassium carbonate, when calcium carbonate is precipitated and potash passes into solution, as shown by the equation:

$$K_2CO_3 + CaH_2O_2 = CaCO_3 + 2KHO.$$

The solution is concentrated by evaporation first of all in iron vessels, and finally to dryness and fusion in silver vessels. It is, however, for the most part now manufactured by the electrolytic method from potas-

POTASSIUM (*Continued*)—

sium chloride. (See Caustic Soda, p. 826.) It is a very deliquescent and caustic substance, and when dissolved in water, great heat is developed. It is used in soap-making, and in the textile and other trades, being prepared in various forms (lumps, sticks, liquid, and pellets), including a solid form of 88/90 per cent. and liquid form of 50° Bè.

Potassium Nitrate or **Nitre** (KNO_3), also known as saltpetre, is largely used as a fertilizer; also for pickling meat, in the manufacture of gunpowder, glass, enamels, and pyrotechnics. It is a white, crystalline salt, readily soluble in water, and is for the most part obtained from Chile nitre by steam-heating a solution of it in admixture with one of potassium chloride (KCl), when a double decomposition occurs, expressed as follows: $NaNO_3 + KCl = KNO_3 + NaCl$. Under the working conditions of the process, most of the NaCl is precipitated in a crystallized form and removed, and the KNO_3 is obtained later by crystallization of the mother-liquor and purification by recrystallization. Other processes of manufacture by the action of nitric acid and nitrogen peroxide upon potassium chloride are dealt with in a paper by Mehring, Ross, and Merz (*Ind. Eng. Chem.*, April, 1929; see also *C.T.J.*, 1929, **84,** 486).

Mohammed Abdul Hamid is of opinion that the fundamental ideas underlying the separation of this compound from associated salts might be easily extended to restore the old Indian manufacture which existed prior to 1860. (See *J.S.C.I.*, 1926, **45,** 915 T.)

A South American mixture of potassium and sodium nitrates is marketed as a fertilizer under the name of "Nitrapo."

Potassium Chloride, Bromide, and **Iodide** (KCl, KBr, and KI) are all white, crystalline salts readily soluble in water. The chloride occurs in the water of the Dead Sea (see p. 725), but is prepared chiefly from the Stassfurt salt deposits in the form of concentrates, there being incidentally a wastage of magnesium chloride estimated at some 800,000 tons per annum. The chloride (muriate) is used as a fertilizer and in compounding some blasting explosives, as it lowers the flame temperature; in one form it is marketed of 80 per cent. strength.

The bromide can be prepared by the interaction of bromine and potassium hydroxide or from iron bromide and potassium carbonate, and, like the iodide, is used in photography and medicine.

The iodide is made, among other methods, by the action of iodine on potassium hydroxide, but a modern process for use on a large scale is described in the *Chemiker Zeitung,* September 4, 1924, and details will be found in the *C.T.J.*, 1924, **75**, 297 and 704. It comprises three stages—viz., the preparation of an iron-iodide liquor consisting of ferroso-ferric iodide, precipitation with potassium carbonate, and purification of the potassium iodide thus produced by crystallization.

Potassium Fluoride (KF), made from potassium carbonate and hydrofluoric acid, forms a white, deliquescent, soluble hydrate with water ($KF.2H_2O$), and finds some use in etching glass.

POTASSIUM (*Continued*)—

Potassium Sulphides include K_2S, K_2S_2, K_2S_3, K_2S_4, and K_2S_5, all of which are soluble in water, and are decomposed by acids, evolving hydrogen sulphide (H_2S). The monosulphide is obtained in red crystalline form of deliquescent character by reduction from the sulphate with charcoal. The sulphides are used as depilatory agents. (See Pearson and Robinson, *J.C.S.*, 1931, p. 1304.)

Potassium Sulphates—The sulphate and bisulphate (K_2SO_4 and $KHSO_4$) are both colourless and crystalline, and to some extent soluble in water, although not so soluble as most of the other potassium compounds. The ordinary sulphate (obtained by fractional crystallization from kainite and by action of sulphuric acid on potassium chloride) melts at 1,072° C., is used in glass manufacture, also as a fertilizer, and in the preparation of alums. The bisulphate is used as a flux. (See *Ind. Chem.*, 1932, viii., 35, and M. Fury, *B.C.A.*, 1932, B, 144.)

Potassium Persulphate ($K_2S_2O_8$) is obtained by the electrolysis of a strong solution of potassium-hydrogen sulphate in a divided cell, when, being sparingly soluble in water, it separates, and can be freed from the associated acid sulphate by recrystallization. It decomposes below 100° C., and is a powerful bleaching and oxidizing agent.

Potassium Sulphite (K_2SO_3) and potassium-hydrogen sulphite (or acid potassium sulphite) ($KHSO_3$) are crystalline salts soluble in water, both of which (particularly the latter) are used in the brewing industry and as sources of sulphur dioxide. (See Sulphites.)

Potassium Metabisulphite ($K_2S_2O_5$) is a white, crystalline salt slightly soluble in water; used in pharmacy and as an antiseptic, its application being dependent upon its high available content of sulphur dioxide. (See article on its uses and manufacture, *C.T.J.*, 1931, **88,** 28.)

Potassium Manganate and Permanganate—See Manganese (p. 561).

Potassium Acetate [$K(C_2H_3O_2)$]—A white, crystalline powder, soluble in water, used in medicine, etc.

Potassium Citrate ($K_3(C_6H_5O)_7,H_2O$) is a colourless, crystalline salt soluble in water and alcohol, and used in medicine.

Potassium Phosphate (KH_2PO_4)—A colourless, crystalline salt used in compounding baking-powders and in medicine.

Potassium-Sodium Tartrate (Rochelle Salt) ($KNa(C_4H_4O_6),4H_2O$)—A colourless, crystalline salt which loses its water at 215° C. and is used as a depilatory and in medicine.

Potassium Sulphocyanate (Sulphocyanide) (KCNS)—A colourless, crystalline compound used in making freezing mixtures and artificial mustard oil.

Potassium Oxalate ($K_2C_2O_4H_2O$) is a colourless, crystalline salt, soluble in water; so also is the potassium-hydrogen oxalate (KHC_2O_4,H_2O) (sometimes called binoxalate and commonly known

POTASSIUM (*Continued*)—
as "salt of sorrel") which is used for scouring metals and as a wood cleanser, and there is an acid potassium oxalate ($KHC_2O_4,C_2H_2O_4,2H_2O$) (also known as quadroxalate).

Potassium Bitartrate ($KHC_4H_4O_6$) is a white, crystalline, soluble salt, used in compounding baking-powders. (See Argol and Tartar.)

Potassium Chromate and **Dichromate**—See p. 191.

Potassium Ferricyanide or **Prussiate of Potash** (**Red**) [$K_3Fe(CN_6)$]—A crystalline, poisonous substance of blood-red colour, readily soluble in water, which forms with solutions of many compounds of the heavy metals, precipitates of characteristic colours; hence its use in dyeing and calico-printing when used alone, or with solutions of iron salts for the production of blue colours on wool and cotton; also used in connection with the discharge of indigo-blue colouring from calico and in the preparation of some pigments. It is made by the action of chlorine upon a solution of the yellow prussiate of potash or by its electrolysis.

Potassium Ferrocyanide, or **Prussiate of Potash** (**Yellow**) ($K_4Fe(CN_6)3H_2O$), is a crystalline, poisonous substance of lemon-yellow colour, readily soluble in water, made by heating a mixture of nitrogenous material such as dried blood, horn, and parings of hides with an equal weight of potassium carbonate and one-third of their weight of iron filings. There are other processes for making it respectively from the "spent oxide" from gasworks (containing cyanogen compounds), from thiocarbamide, and from calcium ferrocyanide by interaction with quicklime. It is manufactured on a large scale for use in dyeing and calico-printing, also in the preparation of Prussian blue and processes of electro-plating and electro-gilding.

POTATO (*Solanum tuberosum,* N.O. Solanceæ)—Potato flour is used in the manufacture of starch, dextrine, glucose, etc., and as a wheat flour substitute. "Modern Methods in the Manufacture of Potato Starch," by A. E. Williams (*C.T.J.*, 1932, **90,** 29 and 54); "'Quality' in Potatoes," by W. H. Parker (*Chem. and Ind.*, 1932, **51,** 94); nature of amylose prepared from potato starch, by Bergmann and Knehe (*B.C.A.*, 1927, A, 342); manufacture of alcohol from potatoes, by E. Lühder (with others) (*B.C.A.*, 1930, B, 880); and C. K. Tinkler on "Blackening of Potatoes after Cooking" (*Analyst,* 1931, **56,** 676). (See also Dextrin, Solanine, and Starch.)

POTATO SPIRIT—See Fusel Oil.

POTENTIOMETRIC ANALYSES—See Volumetric Analyses.

POTTERY—See Porcelain.

POUNDAL—See Force.

POWER is the capacity of exercising force. The economics of power as applied to chemical engineering is the subject of a paper by A. Gibb

POWER (*Continued*)—

(*Ind. Chem.*, 1928, iv., 159), and in a presidential address to the Inst. of Chem. Engineers he dealt with the economics and position of the chemical industries that depend at the present time upon electrical power as a decisive factor (see *The Times*, July 1, 1929, p. 21). "Some Chemical Aspects of Power Production from Mineral Fuels" by J. T. Ward (*Chem. and Ind.*, 1929, **48,** 547). Power transmission discussion at the World Power Conference in 1928. (See *Chem. and Ind.*, 1928, **47,** 1025); article on "Power Plants in the *Power Engineer*, January, 1928; "Power Shovelling" (*C.T.J.*, 1928, **83,** 410); description of the Distillers Co.'s plant at Liverpool (*Ind. Chem.*, 1929, v., 517); *Chemistry in Power Plant*, by W. H. Miles (E. Benn, Ltd.); and *Power Resources of the World* (*Potential and Developed*), published by the Executive Council of the Power Conference(63, Lincoln's Inn Fields, London, W.C. 2).

POZZOLANIC MATERIALS—Volcanic ash. (See Cement.)

PRASEODYMIUM (Pr) **and its Compounds**—Atomic weight, 140·9, and isotope of mass number 141; sp. gr., 6·4754; a little known and extremely rare element of the cerium group occurring in the earth *didymia* and *monazite sand*, and isolated by the electrolysis of its anhydrous chloride. It decomposes water, melts at 940° C.; gives two oxides, one of greenish-white colour (Pr_2O_3), and another nearly black (Pr_4O_7). Its salts include a chloride ($PrCl_3,7H_2O$) and a sulphate ($Pr(SO_4)_3,8H_2O$) green in colour.

PRECIOUS METALS—See description of a precious metal refinery at Acton (*Ind. Chem.*, 1931, vii., 207).

PRECIPITATE—To deposit or fall in the solid state out of a solution. For example, when a solution of sodium chloride is added to one of silver nitrate, the following interaction takes place: $NaCl + AgNO_3 = NaNO_3 + AgCl$, and the silver chloride, being insoluble, is thrown out of solution as a white curdy precipitate.

U. R. Evans has expressed the view that it is possible some precipitates may be truly non-crystalline, the ultimate particles being of the character of glass or super-cooled fluid, but silver chloride, although it has no definite geometrical form, cannot be described as non-crystalline. (See *Chem. and Ind.*, 1925, **44,** 814; also Crystals.)

PREHNITE—Hydrous silicate of alumina and lime, sometimes containing ferric oxide in substitution of part of the alumina, and probably derived from igneous rocks such as porphyrite; found in Scotland, Cape of Good Hope, etc.; crystal system, No. 4, and sp. gr. about 2·8.

PREMIER JUS—See Oleo.

"PREMIER" MILL—A type which, like the "Plauson" mill, can be used for making excellent emulsions, including one of creosote with water, which, it is stated, is so stable that it will stand boiling and freezing without change of composition and is valuable for the preservation of timber. This mill is also available for the intensive mixing of solids with liquids, handling viscid fluids and pastes, the extraction

"PREMIER" MILL (*Continued*)—
of fibrous tissues, regeneration of milk from milk powders, and other purposes. (See Grinding.)

"PREPARING SALT"—See Sodium Stannate, under Tin Compounds.

PRESERVATIVES (Food)—See Foods and Fruits.

PRESSURE (High)—The employment of high pressure in the study of chemical changes as influenced thereby has widened the field of chemistry enormously. Morgan, Taylor, and Hedley have given the results of certain experiments, using various mixtures as catalysts, including zinc oxide, zinc dust and oxide mixed, zinc oxide and copper oxide, zinc oxide and silver oxide, zinc oxide and uranium oxide, zinc chromate, basic zinc chromate alone and mixed variously with cadmium carbonate, copper chromate, and the manganate, tungstate, uranate, molybdate, and vanadate of zinc. It was found that the zinc chromates would probably prove efficient catalysts for methyl alcohol synthesis, using a temperature between 350° and 400° C. with a pressure of about 200 atms.; also that the primary product of the reaction between carbon monoxide and hydrogen at high pressure, using a catalyst of zinc chromate, is formaldehyde, which might react in either of two ways—viz., by further hydrogenation, yielding methyl alcohol, or by undergoing aldol condensation, with subsequent formation of aldehydes containing two or more carbon atoms. (See *J.S.C.I.*, 1929, **48,** 82 T, and *Chem. and Ind.*, 1930, **49,** 742.)

P. W. Bridgman of Harvard University, in course of his investigation of the properties of matter under high pressure, has in some instances employed pressure of 50,000 atmospheres, and other experimenters have studied the results of practically instantaneous explosion pressures of from 15,000 to 20,000 atmospheres, using vessels in which the internal temperatures ranged from 3,000° to 3,500° C., the external parts being at room temperature.

In the study of high pressure reactions, the chief constructional materials used are chromium, nickel-chromium, and chromium vanadium steels up to 500° C., and niochrome (80 to 85 per cent. nickel and 20 to 15 per cent. chromium) for higher temperatures.

In his Hunter Memorial Lecture (*Chem. and Ind.*, 1931, **50,** 109), G. T. Morgan, after dealing with a number of organic syntheses facilitated by high pressure, has expressed the opinion that by the use of lower temperatures secured by the use of more efficacious catalysts, high pressure synthesis will come more closely into line with those associated with the vital activities of plants and animals.

See article on "High-Pressure Reactions," by W. A. Bone (*Trans. Inst. of Chemical Engineers*, vol. 8); "Employment of High Pressures in Chemical Industry," by E. B. Maxted (*Chem. and Ind.*, 1926, **45,** 366); article by H. L. Ramsey (*Ind. Chem.*, 1927, iii., 391); article on "High Pressures in the Manufacture of Synthetic Ammonia" (*Chem. and Ind.*, 1929, **48,** 591); article by P. W. Bridgman (*Ibid.*, **48,** 419); "Organic Synthesis Facilitated by Pressure," by

PRESSURE (*Continued*)—
G. T. Morgan (*Chem. and Ind.*, 1931, **50**, 68); "The Rôle of Catalysts in High-Pressure Syntheses from Producer Gas," by R. K. Floler (*J.S.C.I.*, 1928, **47**, 173 T); "Some Factors in the Design of Experimental Apparatus for Work at High Pressure," by D. M. Newitt (*Ind. Chem.*, 1929, v., 473); description of "The New High-Pressure Gas Research Laboratories" (*Ind. Chem.*, 1930, vi., 53); "Notes on High-Pressure Vessels" (*Ibid.*, 1930, vi., 150); E. N. Gougeon (*Chem. and Ind.*, 1931, **50**, 320); "A Simple Pressure Regulator," by J. Johnson (*J.C.S.*, 1931, p. 2523); "High-Pressure Compresses for Synthetic Ammonia Manufacture" (*Ind. Chem.*, 1932, viii., 56); *The Physics of High Pressure*, by P. W. Bridgman (G. Bell and Sons); Force and Chemical Interactions.

PRESSURE (Atmospheric)—See Air and Barometers.

PRESSURE (Critical)—See Gases.

PRICIETE ($3CaO.4BO_3 6H_2O$)—A boron mineral. (See Colemanite.)

PRICKLY PEAR or INDIAN FIG (*Opuntia*, N.O. Cactaceæ)—This fruit is used in South Africa as a source of industrial alcohol, motor fuel, and fuel for lighting and heating, while the by-products include vinegar, sugar, yeast, oil, and fruit jellies. Some 2,000,000 acres of land in South Africa are said to be infested with the common prickly pear, *O. vulgaris*, which is a native of Virginia and parts of South America. (See Woodman and Wiley on the "Eradication of Prickly Pear by Chemicals" (*J.S.C.I.*, 1931, **50**, 187 T); and Cochineal.)

PRIMULINES—Dyestuffs, being thiazole derivatives. (See Dyes.)

PRINTER'S IRON LIQUOR—See Iron (Ferrous Acetate).

PRINTING—See "Modern Developments in Printing," by L. Wild (*Chem. and Ind.*, 1931, **50**, 179 and 530).

PRINTING INK—See Inks.

PRINTING ROLLERS—Gelatin compositions. (See Riesenfeld and Willstaedt, *B.C.A.*, 1929, B, 693.)

PROCESS DEVELOPMENT—See A. D. Little (*J.S.C.I.*, 1929, **48**, 202 T).

"PRODORITE"—A specially hard pitch-binder which can be moulded and reinforced like ordinary concrete; said to be very useful for dealing with the corrosive gases from superphosphate dens and other kinds of acid-resisting chemical plant. It is described as a true concrete, free from plasticity, consisting of an aggregate of broken stone, sand, and a filler bound up with bitumen pitch. It has been otherwise described as concrete in which the Portland cement is replaced by from 7 to 12 per cent. of this special pitch.

PRODUCER GAS is made by passing air and steam over red-hot coke or coal, thus generating a mixture of carbon dioxide (CO_2) and carbon monoxide (CO), together with some proportion of hydrocarbons, the

PRODUCER GAS (*Continued*)—

nitrogen contained in the air used, and hydrogen from the decomposed steam. It contains about 30 per cent. of carbon monoxide (any ammonia produced from the coal being washed out), and is largely used for many manufacturing purposes on account of its cheapness. (See Gas Producers, Mond Gas, Nickel, and Water Gas.)

"PROMETAL"—A variety of cast-iron specially applicable to the construction of furnace parts.

"PROMOLOID"—A Japanese fertilizer, consisting chiefly of colloidal magnesium silicate, said to promote the yield and quality of vegetables.

PROOF-SPIRIT—Alcohol containing 49·28 per cent. real alcohol by weight, and 57·10 per cent. by volume, having a sp. gr. of 0·920 at 60° F. or 15·66° C.; every additional 0·5 per cent. alcohol above that being described as "1 degree over proof." The factor for calculating proof spirit from volume percentage is 1·7535.

PROPANE—See Hydrocarbons.

PROPENYL—The univalent radical or group $CH_3CH=CH—$.

PROPIONIC ACID ($C_3H_6O_2$ or $CH_3.CH_2.COOH$)—One of the normal fatty acids of small importance as a natural product, said to be contained in the products of wood distillation, also in cocoa-nut milk when turned sour, and in crude oil of amber. It is made by the oxidation of propyl alcohol with dichromate mixture, and is a colourless, oily acid, soluble in water and alcohol, with an odour something like that of acetic acid, of sp gr. 0·987, and b.p. 140·7° C.

PROPIONYL—The acyl group, $CH_3.CH_2.C:O—$, left after removal of HO from propionic acid ($C_3H_6O_2$).

PROPYL—The monovalent radical group C_3H_7, or $CH_3.CH_2.CH_2$.

PROPYL ALCOHOL—See Alcohols (p. 24); Isopropyl Alcohol; and *Ind. Chem.*, 1927, iii., 392.

PROPYLAMINE—See Amines.

PROPYLENE—See Hydrocarbons (Olefines).

PROPYLIDINE—The divalent group $CH_3.CH_2.CH:$.

PROTAMINES—Bodies described as the simplest proteins, including salmine and sturine which are isolated from fish testicles.

"PROTARGOL"—A protein compound of silver, soluble in water and glycerol, used as an antiseptic and in medicine. (See *Analyst*, 1926, **51**, 585.)

PROTEIDS—Otherwise described as conjugated proteins, being combinations of proteins with other bodies, and differing from them in being coagulable by alcohol. They approximate in composition, containing about 53·5 per cent. carbon, 7 per cent. hydrogen, 15·5 per cent. nitrogen, 22·5 per cent. oxygen, and up to about 1·5 per cent. sulphur. Some are soluble in water, others insoluble, but all are soluble in strong acetic acid.

PROTEINS—The name given to a great number of variously classified colloidal, nitrogenous bodies of animal and vegetable origin and albuminous character like egg albumin, seralbumin, chondrine, globulins (such as fibrin and globulin from the lens of the eye), gluteins, histones, protamines, etc., but which, while admitting of some rough classification according to their varying compositions and properties, may be all collectively grouped as albuminoids, and regarded as tissue constituents or builders. They are more or less distinct bodies, the albumin of the duck egg being distinct, for example, from that of the hen egg. They all contain carbon, hydrogen, nitrogen, and oxygen, and some of them sulphur and phosphorus also. Many of these complicated compounds when in solution are coagulated by heat and when subjected to hydrolysis they yield the so-called meta-proteins (at an early stage), later proteoses, peptones, polypeptides, and amino-acids, including glycine, leucine, tyrosine, etc. They are commonly regarded as complexes yielding amino-acids, some twenty of which are stated to be known, but some containing a smaller number of the integers than others, the protein of maize being, for example, deficient in lysine, which is necessary to build up the normal muscle tissues of chickens.

Proteins are amphoteric in character, having both COOH and NH_2 groups—that is, they are capable of acting either as acids or bases—or, in other words, they can combine with positive or negative ions according to the hydrogen-ion concentration of the solution. This property is sometimes termed isoelectric, indicating electric neutrality.

The protein of the food does not become protein of the body, but undergoes hydrolysis during digestion to amino-acids by the action of pepsin, carried further by the pancreatic ferment, and it is from these derivatives that the tissues of the body are built up.

Dry yeast contains about 50 per cent. of proteins, and is used in the preparation of a food product named "*Marmite.*"

References: An American classification is given on pp. 150 and 151 of Couch's *Dictionary of Chemical Terms* (D. Van Nostrand, N.Y.), and the ordinary English one in Bernthsen's *Organic Chemistry* (Blackie and Son, Ltd., Glasgow, 1927); "The Composition and Characterization of Genuine Proteins," by S. P. L. Sorensen (*J.C.S.*, 1926, p. 2995); table giving the percentages of some amino-acids derived from various proteins, by S. Dixon (*Chem. and Ind.*, 1930, **49,** 664); some calculated molecular weights of various proteins based upon various considerations, by E. J. Cohn (with others) (*B.C.A.*, 1925, B, 564); "Protein Degradation," dealing with the formation of nitrogen by the action of sodium hypobromite and its relation with the arginine content, by O. Furth (*B.C.A.*, 1930, A, 939); W. M. Sandstrom (*B.C.A.*, 1930, A, 940); "Structure of the Protein Molecule," by D. J. Lloyd and H. Phillips (*Chem. and Ind.*, 1932, **51,** 163); *Animal Proteins*, by H. G. Bennett (Baillière, Tindall and Cox); and *Chemistry of the Proteins*, by Dorothy J. Lloyd (J. and A. Churchill); Albumins, Enzymes, Polypeptides and Foods.

PROTEOSES—Products of the hydrolysis of proteins, precipitated by ammonium sulphate. (See Albumins and Proteins.)

PROTO—A prefix meaning "first."

PROTOACTINIUM (Pa)—Described as an element of the radio group, of atomic number 91. (See A. V. Grosse (*J. Amer. Chem. Soc.*, 1930, **52,** 1742.)

PROTOCATECHUIC ACID ($C_7H_6O_4$ or $C_6H_3(OH)_2CO,OH$)—A colourless crystalline substance soluble in water, made by heating catechol ($C_6H_4(OH)_2$) with ammonium carbonate; used in photography.

PROTONS—The reputed nucleus parts of chemical atoms, each said to have a total internal energy 1,840 times greater than that of an electron, or about 940,000,000 volts. (See Atoms, Electrons, Elements, and Energy (p. 310).)

PROTOPLASM—See Bioplasm.

PROTYLE (**Primordial Substance**)—Hypothetical ultimate form of matter of which the elements are constituted, and to which they may, in that case, be conceivably reducible. (See Atoms, Elements, and Matter.)

PROUSTITE—A mineral, double sulphide of silver and arsenic ($3Ag_2S.As_2S_3$) found in Arizona, New Mexico, etc. (crystal system, No. 3, and sp. gr. 5·4 to 5·6).

PRUSSIAN BLUE (**Ferric Ferrocyanide**) ($Fe_4(Fe(CN)_6)_3$)—The name of a blue pigment used in dyeing and making inks and paints, made from potassium ferrocyanide and ferric salts. There are various methods available for making the several varieties of Prussian blue (Chinese "Milori" and "bronze blues"), varying with the nature of the raw materials from which the ferrocyanide is obtained, but they may be stated to be based generally upon the action of potassium chlorate and sulphuric acid on a mixture of potassium ferrocyanide and ferrous sulphate in hot solution. A soluble blue, having the formula $KFe[Fe(CN)_6]$, has been described. There is also a process for making Prussian blue from coal gas containing cyanogen, by its action upon solutions of ferrous salts, hydrocyanic acid of the coal gas reacting upon the ferrous sulphide first produced to form Prussian blue. It may also be obtained by the electrolysis of a solution of potassium ferrocyanide, using an anode of iron. It is used in making Brunswick greens and chrome yellows, and is liable to take fire in grinding some mixtures, the ignition temperature of the pure substance being 234° C. A mixture of 20 per cent. Prussian blue and 80 per cent. lead chromate decomposes explosively at 238° C. Prussian blue dissolves in solutions of the normal alkali oxalates, giving greenish-coloured solutions. Notes on these manufactures will be found in the *C.T.J.*, 1925, **76,** 788, and 1927, **81,** 595. (See Astington and Hancock on "Bronzing of Prussian Blue Pigments" (*B.C.A.*, 1932, B, 71); Potassium Compounds (p. 730) and Turnbull's Blue.)

PRUSSIAN GREEN (possibly $K_6Fe_2(CN)_{12}$) is prepared by the long-continued action of chlorine upon potassium ferrocyanide.

"PRUSSIATE CHAR"—A by-product from the manufacture of potassium prussiate, used as a decolourizer.

PRUSSIATES—See Cyanogen (p. 261), Carbonyl Ferrocyanides, and Potassium Compounds (p. 730).

PRUSSIC ACID—See Hydrocyanic Acid.

PSEUDO COMPOUNDS may be generally described as those which approximate in some manner or measure better recognized types; thus the tautomeric forms of certain nitro compounds are known as pseudo-acids—*e.g.*, phenylnitromethane ($C_5H_5.CH_2NH_2$) forms a sodium salt; so there are pseudo-alums, pseudo-morphs, pseudo-solutions, and so on.

PTOMAINES (**Toxins**) are basic bodies or alkaloids resulting from th putrefaction or metabolic decomposition of albuminoids (animal proteins). Reference to some of these, including putrescine and cadaverine, is made elsewhere. The resulting bases corresponding to nearly all the known amino-acids have been isolated. Phenylethylamine ($C_6H_5.CH_2.CH_2.NH_2$) may be viewed as typical, and is derived from the amino-acid phyenylalaine ($C_6H_5CH_2.CH(NH_2)COOH$). A base named sepsine ($C_5H_{14}O_2N_2$[?]), which produces symptoms of ptomaine poisoning in dogs, has been obtained from putrefied yeast. Some, but not all, ptomaines are of toxic character, and they are not all poisonous when taken by the mouth, but food infected by *B. botulinus* is poisonous.

A tainted odour is not a safeguard against the common and dangerous form of food-poisoning caused by the *Salmonella* group of bacteria; at the same time putrid food is not necessarily poisonous, as evidenced by the preference and immunity observed by many persons for "high" game. (See Albumins (p. 19), Bacteria (p. 72), and Toxins.)

PTYALIN—See Saliva.

PUBLIC HEALTH CHEMISTRY—See Hygiene (Chemistry).

PUCHERITE ($BiVO_4$)—A rare mineral vanadium compound of bismuth (crystal system, No. 4, and sp. gr. 6·25).

PULEGONE ($C_{10}H_{16}O$)—A monocyclic ketonic constituent of some essential oils (including pennyroyal, nepetella and pimento oils, and, as has been alleged, Japanese peppermint oil) isomeric with ordinary camphor. It gives a hydrochloride, $C_{10}H_{16}O,HCl$. (See Hugh, Kon, and Linstead, *J.C.S.*, 1927, p. 2585.)

PULP—See Paper.

PULVERIZED FUEL—See Coal and Fuel (Powdered).

PULVERIZERS—See Grinding.

PUMICE-STONE—A cellular or very porous lava of volcanic production, probably derived from felspar, which floats in water, and is composed largely of silicate of aluminium. In a finely powdered state it is used as an abrasive, also in compounding scouring preparations, and as a base for carrying catalysts. The seat of the Italian pumice industry is the volcanic island of Lipari. For some analyses of Etna lava see H. S. Washington (with others), *B.C.A.*, 1926, A, 1223. (See also Koka-Seki and Obsidian.)

PUMILINE—The essential oil from the leaves of *Pinus pumilio* (coniferæ), containing terpenes; used for inhalations.

PUMPKIN-SEED OIL—Composition. (See N. Beliaiev, *B.C.A.*, 1931, B, 210).

PUMPS—Exhaust pumps are contrivances for reducing the pressure within vessels, and thereby creating more or less vacuity. In the filter or water pump, a jet of water under pressure escapes in such a way as to cause air to be drawn by suction from the space to be exhausted.

Many varieties of material are used in the construction of pumps, and have to be selected, of course, according to the physical and chemical properties of the liquids to be dealt with, both in respect of material and construction.

The "Sprengel" pump is an appliance in which mercury running down a narrow tube is used instead of water, and by its means the pressure may be reduced to 0·001mm. of mercury.

The "Gergk" pump of piston type, having valves immersed in oil, gives a vacuity of 0·0002.

The "Töpler" mercury pump is said to give a vacuity of 0·00001 mm. of mercury, and when coupled with the use of charcoal to assist in the absorption of any remaining gas in the vessels to be exhausted, an enormously enhanced result is attained. Even greater claims are made on behalf of the Gaede pistonless pump, which gives a vacuity of 0·0000002 mm.; but the greatest degree of exhaustion is said to be realized by an arrangement in which liquid air and charcoal are used in association, the degree of exhaustion reaching to pressure reducible to 0·0000008 mm. of mercury.

With a backing pump giving a vacuum of 0·2 mm. the new "Vitreosil" mercury condensation pump is said to give a vacuum of 0·000002 quickly and readily.

Varieties of oscillating mercury pumps have been described by Donnelley with others (*J.S.C.I.*, 1927, **46**, 437 T.)

There are "centrifugal," "plunger," "suction," "vacuum," etc., pumps. The "Tungstone" patent pump is one without pistons, and stuffing glands and compressed air or other gas under pressure is the prime mover; the "Kestner" acid pump is without glands or packing.

See "Pumps for Industrial Purposes," by J. Watson (*Ind. Chem.*, 1926, ii., 553); "New Types of Silicon Iron Acid Pumps," by W. Hayhurst (*Chem. and Ind.*, 1930, **49**, 114); certain acid pumps, including the "Meldrum" make (*C.T.J.*, 1929, **84**, 497; 1931, **88**, 67; *Chem. and Ind.*, 1930, **49**, 475); the "Haveg" centrifugal acid pump (*Ind. Chem.*, 1928, iv., 211); the "Wallwin" type, described as a non-chokable one, which will pass through its suction pipe water containing lumps of any material, size, or shape; the Dalton stoneware centrifugal pump (*Ind. Chem.*, 1927, iii., 62); the improved "Ferraris" design of sulphuric acid pump (*C.T.J.*, 1928, **83**, 229); a pump for molten salts (especially caustic soda), by H. Oeltinger (*B.C.A.*, 1928, B, 745); a "Vitreosil" air lift pump, by B. Moore (*Ind. Chem.*, 1931, vii., 201); "Pumping Problems" (*C.T.J.*, 1931, **88**, 596); *Chemical Works Pumping*, by N. Swindon (E. Benn, Ltd., London); *A Practical Treatise on Single*

PUMPS (*Continued*)—
and Multi-Stage Centrifugal Pumps, by R. de Feld (Chapman and Hall, Ltd.); Air Pumps, Compressing Plant, and Vacuum.)

PUNNA OIL, from *Calophyllum Wightianum* (Wall) from the West Coast of Africa, is stated to contain glycerides of the same type as those found in cotton-seed and sesame oils; it is of greenish-yellow colour, with a sap. v. of 187; i.v. (Winkler), 102.

PURINE GROUP—A number of bases, being derivatives of purine ($C_5H_{10}N_4$), including caffeine and theobromine; also so-called cyclic diureides, including uric acid. Purine is crystalline, colourless, and of m.p. 216° C.

"PURIT"—A carbon decolorizer.

PURPLE OF CASSIUS—A purple-coloured body obtained in the form of an impalpable precipitate by adding a solution of tin chloride ($SnCl_2$) to a solution of gold, or by adding a neutral solution of gold chloride to one of the mixed stannous and stannic chlorides. A purple of fine tint is produced when the tin chloride is first of all added to a solution of ferric chloride until a shade of green is obtained, and then adding this mixture very gradually to a solution of gold chloride ($AuCl_3$). The precipitate, when collected and dried, forms the so-called purple or powder of cassius, which is used as a colouring material in the red glass of Bohemia and for colouring enamels; it is regarded by Huber as a mixture of colloidal gold and colloidal stannic acid.

PURPLE OF TYRE—See Tyrian Purple.

PURPURIN ($C_{14}H_8O_5$)—A red colouring matter, being a valuable dye extracted from madder by the same process as alizarin, and separated therefrom by its greater solubility in alum liquor. From strong alcohol it crystallizes in red needles. It is more soluble in water than alizarin, and is produced synthetically from anthracene.

PUS—Creamy matter resulting from inflammation of wounds, and found in abscesses, consisting of serum and degraded tissue, crowded with white corpuscles (leucocytes) which have undergone degenerative change, and generally accompanied with abundant micrococci and bacteria. It is very subject to infection or putrefaction. (See Albumins and Ptomaines.)

PUTREFACTION—The expression by which is indicated a number of hydrolytic and other chemical changes in animal and vegetable compounds brought about by the action of microbes. (See Albumins, Bacteria, Microbes, Ptomaines, and Pus.)

PUTTY—A mixture of whiting (calcium carbonate) and 18 per cent. linseed oil, with or without added white-lead. Mixtures of pure calcium carbonate and acid-free linseed oil are devoid of plasticity, but the necessary gel structure can be secured by the incorporation of about 1 part in 10,000 alumina, or iron oxide.

PUTTY POWDER—Impure stannic oxide, containing about 25 to 50 per cent. of that substance, with from 71 to 46 per cent. of lead oxide, and

PUTTY POWDER (*Continued*)—

4 per cent. of impurities; used in enamelling and for polishing stone and glass. (See Tin (Oxides).)

PYCNOMETER (**Pyknometer**)—A glass vessel standardized to determine the specific gravities of liquids by weight. A description of one form will be found in the *Ind. Chem.*, 1925, i., 410.

PYOCYANINE—The blue pigment produced by *Bacillus pyocyaneus* of formula $C_{26}H_{24}O_2N_4$. (See Wrede and Strack (*J.C.S. Abs.*, 1925, I., 844) and *B.C.A.*, 1929, A, 580; and Bacteria.

"PYRALINE"—An American cotton preparation used for the same purposes as "Fabrikoid." (See "Fabrikoid.")

PYRARGYRITE—A natural compound of antimony and silver sulphides (Ag_3SbS_3), mined in the United States of America and New Mexico (crystal system, No. 3, and sp. gr. about 5·8).

PYRENE ($C_{16}H_{10}$)—A crystalline hydrocarbon of m.p. 149° C. accompanying chrysene, etc., contained in the distillate from coal tar coming over above 360° C.

The same name is given to a make of fire extinguisher.

PYRETHRUM—See Insecticides, Insect Powder, and "Pysect."

PYRETOL (**PYRETHRIN**)—A name sometimes given as that of the active principle of pyrethrum—very poisonous to cold-blooded animals. (See Insect Powder.)

"PYREX"—See Glass.

PYRIDINE (C_5H_5N or $CH(CH.CH)_2N$)—A practically colourless, liquid, basic substance of penetrating, sharp odour, contained in tar oil, and present also in tobacco smoke; sp. gr. 0·9746, b.p. 115° C.; soluble in water, alcohol, ether, benzol, etc. It can be extracted in association with some of its homologues from the lower-boiling fractions of tar distillates, after removal of the tar acids, by agitation with sulphuric acid in which they dissolve, and in a pure state by heating its carboxylic acid with lime. It is used to some extent as a remedy for asthma, a denaturant for alcohol, and as a valuable solvent in the rubber, paint, and other industries. Chemically it has an heterocyclic ring constitution in which nitrogen replaces a carbon in benzene.

The pyridine derivatives exhibit isomerism similar to the benzene derivatives. (See C. Ab-der-Halden, *B.C.A.*, 1929, B, 463; and Picolines.)

PYRIDYL—The univalent radical $N(CH_4)C$, having a similar relation to pyridine as phenyl to benzene.

PYRITES—The mineralogical name of a number of natural compounds consisting of sulphides (chiefly iron and copper). There is a large consumption of pyrites in connection with the manufacture of sulphuric acid. In 1913 Europe provided 90 per cent. of the total production, Spain and Portugal furnishing 60 per cent., Norway ranking next, while Italy and France produced considerable quantities. Smaller amounts are mined in Roumania, Ireland, and Cornwall. Iron pyrites (FeS_2) (crystal system, No. 1, and sp. gr. about 5·0) exists in many

PYRITES (*Continued*)—

countries and in several varieties. A large proportion of pyrites is so-called cuprous pyrites (Cu_2S,Fe_2S_3) (crystal system, No. 2, and sp. gr. about 4·2). Many are of arsenical character; one of them, named *mispickel,* has the composition $FeAs_2,FeS_2$, and others contain a notable quantity of nickel.

The gold, silver, and copper contained in pyrites used in the sulphuric acid manufacture are recovered from the burnt ore. The Rio Tinto iron pyrites contains about 50 per cent. sulphur, 40 per cent. iron, from 1·5 to 3·80 per cent. copper, and 1 oz. 4 dwts. of silver per ton; the Tharsis pyrites, about 3·5 per cent. copper and 15 dwts. silver; and the San Domingo (Mason's), about 3·70 per cent. copper and 15 dwts. of silver. In the recovery of the copper great care has to be taken to first of all get rid of the arsenical constituent. The "Freeman" flash roasting process for production of SO_2 from pyrites in air-suspended form is referred to in *C.T.J.*, 1931, **88,** 1. (See also Copper (p. 235), Iron (p. 491), and Pyrrhotin.)

PYRO—A prefix denoting high-temperature determination instruments; also some products—for instance, pyrogallol, pyroligneous acid and other substances derived from dry distillations. (See Pyrometers.)

PYROCATECHOL (**Pyrocatechin**) (**Ortho-dioxybenzene**)—See Catechol.

PYROGALLIC ACID (**Pyrogallol** or **Trihydroxybenzene**) ($C_6H_6O_3$ or $C_6H_3(OH)_3$) can be obtained from gall nuts, but better by heating gallic acid ($C_7H_6O_5$) with water in an autoclave, thus eliminating carbon dioxide. It is a white, crystalline, trihydric phenol of the monoclinic-prismatic class, m.p. 132·5° C., and can be sublimed without decomposition; is soluble in water, and is a powerful reducing agent for silver salts, which gives it a use in photography as a developer. Dissolved in alkali, it has a great affinity for oxygen (see Nitrogen, p. 611, and Organic Analyses, p. 648), and so is much used in gas analysis. With a solution of a ferrous salt it produces a beautiful indigo colour. Commercial samples exhibit a m.p. of from 125° to 132° C. (See Tannins.)

PYROLIGNEOUS ACID—The crude acetic acid liquor obtained, in association with tar, creosote, naphtha, and other products, by the dry distillation of wood, and from which it has to be separated; after which it is neutralized by lime, and the calcium acetate thus obtained is then distilled with hydrochloric acid, yielding the acetic acid as distillate (See Padovani and Mariotti on "The Origin of the Acetic Acid" (*B.C.A.*, 1930, B, 750); Acetic Acid and Wood (Distillation).)

PYROLUSITE—Mineral Manganese Dioxide (see p. 560).

PYROLYSIS—Process of chemical change effected by heat. The pyrolysis of carbon compounds is the subject of a monograph by C. D. Hurd (Chemical Catalog. Co., Inc., N.Y.); see also report of lecture by A. E. Dunstan (*Chem. and Ind.*, 1931, **50,** 225) dealing with the thermal decomposition of the lower hydrocarbons.

PYROMETERS—Instruments for determining high temperatures, such as those of furnaces and the fusing-points of metals. They are of various

PYROMETERS (*Continued*)—

classes, including the "contact" or "immersion" type (being so called because one part of the pyrometer is immersed in the heated material); and "distance" types, in which there is no such immersion. The mercury thermometer is a simple form of the first-named class, and can be applied in respect of temperatures up to 500° C., when the stem is filled with nitrogen at 2 atmospheres pressure to prevent distillation of the mercury. Mercury steel tube thermometers are also made available for determining temperatures from $-30°$ up to 540° C.

The thermo-electric pyrometer is based upon the fact that if two dissimilar metals are joined together, the circuit completed by a wire, and the junction heated, a very small electric current flows round the circuit. In other words, the indication depends upon the electric current generated by a junction of two dissimilar metals in wire form, at the tip of which is a rod enclosed in a protecting tube, and this receives the heat and is termed the "hot junction," while the other ends of the two wires are outside the source of heat ("cold junction"), the electro-motive force set up being proportionate to the temperature of the heated part. The E.M.F. is measured by means of a delicate galvanometer, the reading being referred to a scale graduated in terms of temperature degrees.

The temperature registered on an indicator is the difference between that of the two junctions. Many combinations of metals are available, one of the best consisting of a platinum wire and a platinum-rhodium wire, giving accurate indications over a large range of temperatures.

A base metal couple for determining moderately low temperatures is made up of a copper and a "constantan" wire (an alloy of 40 per cent. nickel and 60 per cent. copper). Other thermo-couples for measuring up to about 900° C. are made from a nickel wire opposed to a nickel-chromium alloy wire.

Nickel-chromium alloys are stated to give the highest electro-motive force in commercial use, and are useful for temperatures up to about 1,360° C. Watson and Abrams have described a tungsten-graphite thermo-couple having an accuracy of about $\pm 10°$ up to 1,600° C. (*B.C.A.*, 1928, B, 822), and a pyrometer for measuring temperatures by means of a colour change is described by G. Naeser (*B.C.A.*, 1929, B, 381). For higher temperatures so-called "radiation pyrometers" are used. In these, the heat is focussed by a mirror on to a small thermo-couple or on to a metallic spiral, so that the instrument does not come into contact with the hot body.

The "Pyro" instrument is described as an insertion appliance consisting of a thermo-couple and indicator combined, which gives a temperature reading in 8 to 10 seconds, useful in foundry work, etc., while the "Pyroversum" instrument applicable for temperatures ranging from 500° to 1,400° C. is useful in connection with molten metals. (See "Industrial Pyrometry" (*Chem. and Ind.*, 1925, **44,** 1157); "Points in Pyrometry" (*C.T.J.*, 1927, **80,** 64); E. Schröer, (*B.C.A.*, 1928, A, 984); *Pyrometers*, by E. Griffiths (Sir Isaac Pitman and Sons, Ltd., Lond.); Electricity (Thermopile, p. 298), and Thermometers.)

PYROMORPHITE (Green Lead Ore) ($3Pb_3P_2O_8,PbCl_2$)—A natural lead compound (chloride-phosphate) found in some of the U.S.A.; crystal system, No. 3; and sp. gr. 6·5 to 7·0.

"PYRONIUM"—A proprietary opacifying substitute for tin oxide, used in making enamels, 3 per cent. of which and 3 per cent. of tin oxide give better results, it is claimed, than 8 per cent. of tin oxide alone in leadless enamels, and is much cheaper.

PYROPHORIC ALLOYS—These include ferro-cerium, "Auermetal" (an alloy of iron and "misch metal"), and "Kunheim" (a misch metal). (See Ferro-cerium (p. 497) and N. F. Budgen (*C.T.J.*, 1924, **75**, 761).)

PYROPHORUS (Pyrophoric)—The character given to materials which readily fire upon exposure to air, such as finely divided iron, cobalt, and nickel, as obtained from their oxides by reduction with hydrogen. The large surfaces thus exposed tend to rapid oxidation, attended with a large generation of heat sufficient to bring about incandescence.

PYROPHYLLITE (Pencil Stone)—A mineral hydrous aluminium silicate ($AL_2O_3,4SiO_2,H_2O$) somewhat like talc; used for making slate pencils, also as a ceramic raw material, and in the manufacture of "talcum" toilet powders.

"PYRORUE"—A proprietary fire-resisting roofing material.

PYROTECHNY—See Fireworks.

PYROXYLIC SPIRIT—Wood spirit.

PYROXYLIN is typical of a number of substances used in competition with oil products, in the preparation of artificial leather cloth, lacquers, enamels, book-binding materials, and oil varnishes, and consists of a solution of nitrated cellulose in a solvent of comparatively high boiling-point, at times mixed with castor oil, linseed oil, or nitrated castor oil to impart body and flexibility to the product.

So-called "finishes" or colouring matters are employed in perfecting these articles, such as "Coricol."

The solvents comprise ethyl, butyl, and amyl acetates, various alcohols, acetone, benzol, etc., di-ethyl carbonate, tri-cresyl phosphate, etc., and are used as plasticizers and stabilizers; various resins and pigments are also often incorporated in preparing pyroxylin lacquers and compositions. Pyroxylin is a form of gun-cotton nitrated to the extent of from 11 to 12·5 per cent. (in contrast with the explosive gun-cotton, which is nitrated to a higher degree), and thus becomes insoluble in some of the usual solvents. (See H. S. Garlick on "Solvents and Diluents for Pyroxylin Lacquers and Enamels" (*Ind. Chem.*, 1926, ii., 437 and 499); a table by him giving some properties of the commoner pyroxylin solvents (*Ibid.*, 1927, iii., 54); and *C.T.J.*, 1926, **79**, 342); *Pyroxylin Enamels and Lacquers*, by S. P. Wilson (Constable and Co., Ltd.); also Cellulose, Collodion, Dopes, Explosives (Gun-cotton), Lacquers, Nitrocellulose, Plasticizers, Pyroxylin, and Varnishes.)

PYRRHOTIN (Pyrrhotite)—Magnetic pyrites of varying composition and crystalline character found in many districts.

PYRROLE (C_4H_4NH)—A secondary base constituent of bone oil and coal tar. It is a yellowish, sublimable, liquid, basic body of the furane group, soluble in alcohol and ether; sp. gr. 0·9669, and b.p. 130° C.

PYSLLIUM SEED (*Plantago pysllium*), occurring in France, Spain, and Italy, and grown in the U.S.A.; is used in medicine in the treatment of constipation by reason of its mucilage content, and has some industrial application in the "marbling" of books. (See *C.T.J.*, 1931, **88,** 84.)

PYTHAGORAS (CERAMIC MASS)—See Porcelain, p. 722.

QUADRIVALENT (Tetravalent)—See Valencies.

QUALITATIVE ANALYSIS is the term applied to the methods used for ascertaining the nature of the constituents of substances. (See *Fresenius' Qualitative Analysis*, 17th edition (J. and A. Churchill, London); manual by G. S. Newth (*Qualitative and Quantitative*) (Longmans, Green and Co.); *Essentials of Qualitative Chemical Analysis*, by J. C. Ware (Chapman and Hall); and Reagents.)

QUANTITATIVE ANALYSIS is the term applied to methods used for determining the amount of each constituent of any substance. (See *Fresenius' Quantitative Analysis*, 7th edition (J. and A. Churchill); *Elementary Analytical Chemistry*, by Clowes and Coleman, 11th edition (J. and A. Churchill); textbook by W. T. Hall (Chapman and Hall, Ltd.); Organic Analyses and Volumetric Analyses.)

QUANTUM THEORY—This is based upon the absorption and emission of energy which occurs in pulsations of inconstant value, but always in multiples and never in fractions, the quantum being denoted by (e) and being proportional to the vibration frequency of the radiations produced by the "resonator"—that is, the atoms and electrons, the former of which produce the infra-red or heat waves, and the latter the ultra-violet radiations; $e = h\nu$, h being a universal constant (Planck's constant) of numerical value $6{\cdot}5 \times 10^{-27}$ erg-seconds. The quantum is otherwise described as a fundamental entity from which the age, the speed, the history, of the various cosmic masses can be elucidated. (See "Chemistry and the Quantum Theory," by Niels Bohr (*J.C.S.*, 1932, pp. 349-384); *Quantum Chemistry*, by A. Haas (Constable and Co., Ltd); *Quantum Theory*, by W. C. McC. Lewis (Longmans and Co.); Southern's *Electricity and the Structure of Matter* (Oxford Univ. Press); Codd's translations of *Wave Mechanics and the New Quantum Theory*, by A. Haas (Constable and Co.); *The Principles of Quantum Mechanics*, by P. A. M. Dirac (Oxford Univ. Press: Humphrey Milford, London); *Quantum Theory*, by F. A. Lindemann (Clarendon Press, Oxford); see also Bohr's Theory and Relativity.)

QUARTZ—Anhydrous crystalline forms of silica sometimes met with chemically pure (crystal system, No. 3, and sp. gr. 2·5 to 2·8). Rock crystal is a variety of water-white character, used in making lenses for spectacles; other varieties are tinted, yellow ones being known as "false topaz," whilst amethyst is purple or violet. "Common quartz" occurs also in many varieties, some of which are opaque; others more or

QUARTZ (*Continued*)—

less transparent, "milk quartz" being somewhat opalescent, and "cat's-eye" in yellow and green forms. The compact type of quartz includes the green chrysoprase (a kind of hornstone) and jasper of several shades (brown, yellow, and red) containing iron. The chalcedonies are also members of the quartz family of minerals, being mixtures of crystalline and amorphous silica, including cornelian, agate, and onyx. Fused quartz obtained by electric heating is now used to make vessels which resist sudden heating and the action of acids, being employed among other applications for the concentration of sulphuric acid. Quartz is stable at all temperatures below 870° C. (see E. W. Smith and H. M. Spiers, *Chem. and Ind.*, 1928, **47**, 1278), and many samples of fused quartz show phosphorescence when heated after illumination by ultra-violet light (Bailey and Woodrow, *B.C.A.*, 1929, p. 240). (See also E. R. Berry (*Chem. and Ind.*, 1926, **45**, 35); Glass, Kieselgühr, Opal, and Silica.)

QUARTZ MERCURY VAPOUR LAMP—See X Rays (p. 1001), and improved pattern (Forbes and Heidt (*J. Amer. Chem. Soc.*, 1931, **53**, 4349).

QUASSIA WOOD (**Bitter Wood**) comes from a tree (*Picræna excelsa*, of the natural order *Simarubaceæ*) which grows in Jamaica and the West Indies. Surinum quassia (from *Quassia amara*) contains about 0·03 per cent. of a very bitter crystalline substance named quassiin ($C_{10}H_{12}O_3$), which is soluble in alcohol and to a smaller extent in water. Infusions of the Jamaica wood are used in medicine and as a bitter.

QUEBRACHO EXTRACT, used in tanning and dyeing as a substitute for *catechu* and *sumach*, is obtained from the wood of trees (*Aspidosperma quebracho*, of the N.O. Apocynaceæ) which grow abundantly in the rich Chaco forests of Bolivia, Brazil, and the River Plate districts of Argentine and Paraguay. Three varieties of quebracho are known—viz., the "Colorado" or red (*chaqueño* and *santiagueño*), the "blanco" or white, and the "inale," or strong quebracho, the "Colorado" variety by far the most important, being pre-eminently the source of the tannin extract of commerce. According to one account, 1 ton of extract is obtained from 4·75 tons of logs. The dry extract contains about 65 per cent. tannin, and a liquid extract is made containing about 35 per cent. tannin and other constituents, quebrachine and aspidospermine. In the preparation of this extract, the heart-wood, containing from 20 to 24 per cent., is used, the sap-wood (outer section), containing 3 to 4 per cent., and the bark, containing 6 to 8 per cent., being neglected. The production for 1919 amounted to upwards of 170,000 tons.

In addition to the natural untreated extracts, there are now made so-called sulphited extracts by what is known as Renner's process, marketed as the "Crown," "Bestanino," etc. (See W. Vogel, *B.C.A.*, 1926, B, 375; and Yohimbine.)

QUERCITIN ($C_{15}H_{10}O_7.2H_2O$)—A brown crystalline substance of m.p. 313° C., soluble in alkaline solutions, and used in dyeing; prepared

QUERCITIN (*Continued*)—
from quercitrin, and, according to T. Weevers (*B.C.A.*, 1931, A, 131), can be isolated from the leaves of *Magnolia Yulan var. Soulangiana*. (See J. Allan and R. Robinson (*J.C.S.*, 1926, p. 2334); "The Position of the Sugar Nucleus in the Quercetin Glucoside," by Attree and Perkin (*J.C.S.*, 1927, p. 238); also Quercitrin.)

QUERCITOL ($C_6H_7(OH)_5$), or so-called acorn-sugar (a polyhydric phenol) is a colourless, crystalline, sweet substance extracted from acorns. It is soluble in water, optically active, and melts at 235° C.

QUERCITRIN ($C_{21}H_{22}O_{12}$,$2H_2O$)—A yellow crystalline dyestuff (flavonol) of glucoside character extracted by alcohol from the bark of the *Quercus tinctoria*, also known as dyer's oak (a native of North America), which yields quercitin ($C_{15}H_{10}O_7$) and rhamnose ($C_6H_{12}O_5$) upon hydrolysis. Quercitrin has also been found present in the fresh leaves of *Camellia theifera* and in dried tea (to the extent of about 0·1 per cent.).

QUERCITRON—The powdered bark of *Quercus tinctoria*, the extract of which contains quercitrin, together with other substances; used in tanning and in dyeing textiles.

QUICKLIME—See Calcium Compounds.

QUICKSILVER—See Mercury.

QUILLAIC ACID—See Saponins.

QUILLAYA (**Quillaja**, **Quillia**, **Quillaïa**)—The dried inner and other parts of the bark of *Quillaja saponaria* or soap-wort, from Bolivia, Peru, and Chile, which yield a soapy kind of infusion containing saponin, which is severally used for washing, as a foam producer in soft drinks, for shampooing, and as an emulsifier. (See Saponins.)

QUINANIL—A drug exhibiting bactericidal properties more active than acriflavine. (See *Lancet*, November 9, 1929.)

QUINHYDRONE ($C_6H_4O_2 + C_6H_4(OH)_2$) is a green crystalline, additive substance used in making determinations of soil reaction. (See *p*H Values.)

QUINHYDRONES—Addition products of quinones and hydroquinones.

QUINIC ACID ($C_7H_{12}O_6$)—A white crystalline substance found in coffee beans, quinine bark, the common holly, the leaves of some conifers, and the cedar; soluble in water and alcohol; m.p. 160° C.

QUINIDINE—See Cinchona.

QUININE—See Cinchona.

QUINIZARINE (**Dihydroxy-anthraquinone,** 1 : 4) ($C_6H_4(CO_2).C_6H(OH)_3$)—An orange red crystalline substance, m.p. 194° C., soluble in alcohol and ether, used in production of green and other dyestuffs.

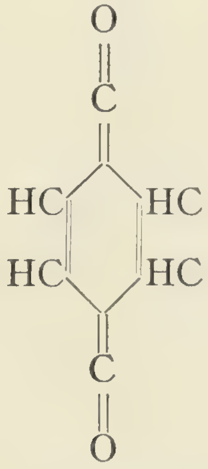
QUINOL—See Hydroquinone.

QUINOLINE (C_9H_7N or $C_6H_4.CH:CH.N:CH$)—A colourless, highly refractive liquid of peculiar characteristic odour, present in coal tar

QUINOLINE (*Continued*)—
and bone oil, and produced synthetically among other methods from aniline. It can also be made from cinchonine. It is a tertiary amine of b.p. 239° C. and sp. gr. 1·08; soluble in water and alcohol; used in medicine and for preserving anatomical specimens. (See F. A. Mason on "Quinoline Dyes" (*Ind. Chem.*, 1930, vi., 75 and 120); and paper by G. M. Dyson on "The Chemistry and Chemotherapy of the Quinoline and Isoquinoline Compounds" (*Ind. Chem.*, 1926, ii., 221).)

QUINONES—A group of yellow compounds used in dyestuffs, obtained from benzene and its derivatives by methods which replace 2 atoms of hydrogen by 2 of oxygen—for example, quinone (benzoquinone) ($C_6H_4O_2$ or $CO(CH.CH)_2CO$), which is prepared from a solution of quinol by the addition of chromic acid, and also made by an oxidation process from aniline. It crystallizes in yellow needles, is soluble in alcohol and ether, and melts at 116° C.

The quinoid formula illustrates the constitution of para-benzoquinone, and exhibits the characteristic arrangement of double bonds:



The bactericidal action of certain quinones is dealt with by G. T. Morgan and E. A. Cooper (*J.S.C.I.*, 1924, **43,** 352 T).

Toluquinone ($C_6H_3(O_2)CH_3$) and naphthaquinone ($C_{10}H_6O_2$), in common with benzoquinone, are used in so-called quinone tannage.

QUINTESSENCES—See Perfumes.

R—An abbreviation for any monovalent radical.

R. SALT—An intermediate, being the sodium salt of beta-naphthaldisulphonic acid.

RACEMATES—Salts of racemic acids. Their existence in liquid forms is the subject of a paper by A. N. Campbell. (See *J. Inst. Chem.*, 1930, part 2, p. 102; and Racemic Acid.)

RACEMIC ACID [$(C_4H_6O_6)_2 2H_2O$]—A transparent crystalline (para) form of tartaric acid ($C_4H_6O_6$) obtained from tartar mother-liquor, devoid of the power of turning the plane of polarized light, and therefore termed "inactive." It is soluble in water, melts at 205° C., and admits of division into two modifications having equal but opposite rotatory powers: the one known as dextro-tartaric acid, which turns the

RACEMIC ACID (*Continued*)—
polarized light plane to the right; and the other as lævo-tartaric, which affects it to the left. Its salts are termed racemates and exhibit differences from the tartrates in solubility, m.p.s, and other respects. (See Tartaric Acid.)

RACEMIC COMPOUNDS are mixtures of equal parts of the dextro and lævo modifications (isomers) of compounds, and are, in consequence, optically inactive—racemic acid, for example.

RACEMIZATION—Rendering optically active substances inactive during or without group displacement, as, for example, by heating. (See A. N. Campbell on "The Existence of Liquid Racemates" (*J.C.S.*, 1929, p. 1111) and Walden Inversion.)

RADIANT ENERGY—Light, radiant heat, and electrical waves. The mechanical effects of radiant energy are measured by an instrument termed a "radiometer," whereas minute changes of radiant energy are detected by the radiomicrometer (a sensitive thermopile). (See Photons and Radio-Activity.)

RADIANT HEAT—A form of radiant energy. (See Heat and Radio-Activity.)

RADIANT MATTER—See Radiations and Radio-Activity.

RADIATIONS—The complete spectrum of radiations is stated to extend uninterruptedly over sixty octaves, the wave-lengths ranging as given under that heading. Clerk Maxwell was of opinion that light waves were electro-magnetic vibrations, the elasticity being electric and the inertia magnetic; while the view is now held that radiations consist of corpuscular photons of wave-like character carrying energy and momentum. Hertz produced electromagnetic waves which physicists consider as fundamentally identical with light waves, but all such phenomena are exhibited in a material atmospheric field, and are probably dependent upon the employment of matter: they cannot be produced without it, and chemistry takes no cognizance of a hypothetical immaterial ether. (See report of Sir J. Jeans' lecture, *The Times*, December 3, 1931; *Radiation in Chemistry*, by R. Allan Morton (Baillière, Tindall and Cox, London); and *Matter and Radiation*, by J. Buckingham (Oxford University Press); also Ether, Force, Matter, Photons, Radio-Activity, and Wave Lengths.)

RADICALS (**RADICLES**)—Groups of atoms which behave in replacement value in chemical combinations as atoms—for example, the group CH_2 in the homologous "paraffin" series of hydrocarbons; the group HO in the alcohols; the group C_3H_5 (glyceryl) in fats; the group NO_2 in nitric acid and many explosives; and the group SO_3 in sulphuric acid. Radicals may be mono, di, or tri-valent, etc.—that is to say, capable of replacing one, two, three or more monovalent atoms. In the case of nitric acid (HNO_3), the constitutional formula is therefore expressed as water in which an atom of hydrogen is replaced by NO_2—viz., H,NO_2,O; that of ethyl alcohol (C_2H_6O) as C_2H_5HO; and sodium ethoxide as C_2H_5NaO.

RADIO-ACTIVITY is a phenomenon, formerly explained as the emission of radiant energy, but now as dependent upon the expulsion of certain electrons from substances, and the apparent conversion of one kind of matter into another. In other words, radio-active substances are continually giving off particles at very high velocities, these particles being, it is alleged, the nuclei of helium atoms, each atom of mass carrying two positive charges of electricity. This is done without materially disturbing the general character and properties of the residual substance in its relation to the groupings (when dealing with elements) of the periodic law (see Lead). In other words, elements may exist generally identical in chemical and physical properties, but having different atomic or mass weights (see Isotopes).

Crookes originally found that when an electric current was passed through a glass tube previously exhausted of air to a great extent, certain rays looking like light pass from the cathode to the anode, although the anode is the pole at which the current enters. These rays or emanations, called "radiant matter," are able to drive a little vane placed in their path—that is, to exercise some small mechanical pressure—and are now regarded as electrons or units of negative electricity, and will pass, as afterwards ascertained, through thin sheets of metal. These cathode rays may be made to converge by the use of an aluminium cup, thus producing a green phosphorescent spot on the glass. They travel in straight lines, their velocity increasing with their flight along the lines of electric force, and finally sufficing to ionize or split up the remaining gas molecules in the nearly exhausted space of the vessel into ions carrying positive and negative charges respectively, attended with illumination; they cast a strong shadow from any intervening object placed in their path; they also develop great heat, which may rise to the melting-point of platinum, and at the most extreme vacua the electrons hit the glass walls of the containing vessel, producing a green or blue fluorescent patch which emits X rays. It may, all the same, be regarded as a transformation of electrostatic force into other forms of energy, attended with consequent effects upon the content-matter of the vessel, small though its amount is.

The so-called X rays are a form of light lying beyond the visible end of the spectrum (see Röntgen Rays), and Becquerel, in his search for the possible emission of Röntgen rays by fluorescent substances, encountered rays which are considered to be corpuscular. For example, a double salt of uranium and potassium, without exposure to light, was found to emit rays which affected a photographic plate and rendered the surrounding medium an electrical conductor. These rays, like the cathode rays, travel in straight lines, and can traverse wood, paper, and some metals, including aluminium. This was the first ascertained instance of so-called radio-activity, and this discovery was followed by that of Curie and his wife, to the effect that the activity of the uranium compounds is due to the presence in them of some other very active substance—viz., radium, which proved to be a million times more active than uranium.

RADIO-ACTIVITY (*Continued*)—

Then it was found that radium itself emits three different types of radiation: one known as the alpha rays, which are unable to pass through a few sheets of paper; another, the beta rays, which can be cut off by a thick sheet of lead; and the gamma rays, of more intensely penetrating character. The alpha rays are regarded as positively charged atoms of helium, the beta rays as negatively charged electrons identical with Crookes's cathode rays, whilst the gamma rays are of extremely short length, very penetrative, and supposed by Rutherford to be derived from motions of alpha particles in the nuclei of atoms. More recently Professor Millikan has claimed discovery of a new ray much shorter than the gamma rays, having a wave length of 0·0004 Angstrom units, and of extraordinary penetrating power (N.B.—0·000001 millimetre = 10 Angstrom units); and W. D. Coolidge has described some remarkable high-voltage cathode rays made with a high vacuum tube, capable of bringing about a number of chemical changes, such as the solidification of castor oil, the bleaching of sugar, etc., and biological effects.

Uranium is a typical radio-active substance, and by the loss of an alpha ray is viewed as transformed to a modified element, which by the loss of a beta ray is again changed into a further modified elemental form, thus illustrating the atomic changes referred to under the respective headings of Atoms, Elements, and Radium. It is surmised that there are elements which decompose more readily than uranium, and in so doing give off more heat; they must have greater atomic weights and their radiations be of shorter wave lengths than those of the known radio-active elements, the newly discovered cosmic radiations being of this type.

According to Rutherford, the α-rays obtained from the nuclei of helium atoms constitute a powerful and effective agent for disintegrating and simplifying the nuclei of atoms generally, being expelled with great velocity and energy. Aluminium, phosphorus, and fluorine, for example, are stated to give off positively charged hydrogen nuclei when bombarded in this way. He supposes that helium is one of the bricks of which the heavier atoms are built up, and that hydrogen is one of the products of the disintegration of oxygen. (See his paper, *Phil. Mag.*, 1927 [vii.], **4**, 580-605.) In his recent lectures at the Royal Institution he stated that it had been found the α particles appear to be mainly homogeneous in velocity, but that by use of a gigantic electromagnet of recent design the alpha particles can be bent into some part of a semicircle, and although they then proved to be homogeneous to a high degree, in the case of one element—viz., thorium—they consisted of a number of distinct groups, each characterized by a definite speed.

Millikan has come to the conclusion that radio-disintegration is a process that can only take place in respect of very few of the very heavy and rare elements. (See Millikan's "Messel Memorial Lecture" on "Available Energy" (*J.S.C.I.*, 1928, **47**, 288-292 T); and "Chemicals and the Radio Industry" (*C.T.J.*, 1931, **88**, 477, and **89**, 157).)

RADIO-ACTIVITY (*Continued*)—

The β-ray is stated to have been identified by Sir J. J. Thomson as the particle of negative electricity.

Among the outstanding problems to be satisfactorily solved is the nature and structure of the nuclear parts of atoms, one surmise being that they are built up of hydrogen nuclei and electrons, and that the phenomena of radio-activity are due to an explosion in the nucleus of atoms, and not to the electrons. (See J. Chapman's book, Technical Primer Series (Sir Isaac Pitman and Sons); *A Manual of Radio-Activity,* by Hevesy and Paneth (Oxford University Press); *Radio Elements and Isotopes, etc.*, by K. Fajans (McGraw-Hill Publishing Co., 1931); Light, Photons, Röntgen Rays, Transmutation, and Wave Lengths.)

"RADIOSTOL"—A preparation of irradiated ergosterol.

RADIUM (Ra)—Atomic weight, 225·9. Radium is a very rare, bright, white metal, m.p. 700° C., the chief sources of which are *carnotite* and *pitch-blende* (minerals found in Cornwall, Colorado, Turkestan, Madagascar, Utah, the Belgian Congo, Olary in South Australia, Ontario, Czecho-Slovakia, and elsewhere, 500 tons of Colorado *carnotite* yielding about 1 gramme of radium). Radium also occurs in *autonite,* a hydrated calcium-uranium phosphate found in Portugal, and in *torbernite,* a hydrated copper-uranium phosphate.

It has remarkable properties, and is supposed to be an atomic decomposition product or derivative of the metal uranium, resembling barium in its chemical properties, and yielding crystalline salts, which are luminous in the dark, radio-active, and emit heat; they are thus able to maintain a temperature higher than that of their surroundings.

The radium family comprises uranium, ionium, radium, actinium, and polonium, all of which are severally referred to in this work. The chloride ($RaCl_2$) is a soluble, yellowish-white, crystalline salt, which, mixed with calcium sulphide or the native zinc sulphide, *wurtzite,* is used in making luminous paints; whilst the bromide ($RaBr_2$) (in which form radium is marketed) is a white crystalline salt similarly employed, and both are used in medicine (chiefly in the treatment of cancer).

The radiations of radium are used as a curative agency in medical practice, and its rays are very destructive of animal tissues. In emitting these radiations it is regarded as undergoing spontaneous decomposition, giving out heat continually, and yielding some seven successive radio-active disintegration products, including niton, radio-lead (see Lead), and helium. (See Atoms, Elements, and Radio-activity.)

It has been estimated that, in all, Europe has produced about 40 grms. and America from 120 to 130 grms. radium, the commercial value being about £20,000 per grm. and the consumption between 25 and 30 grms. per annum.

Radium is stated to perpetually emit three kinds of rays—α, β, and γ; the α-rays consisting of helium atoms carrying a positive electric charge, and thereby converted into niton. In other words, the radium atom

RADIUM (*Continued*)—
of atomic weight 226, expelling helium of atomic weight 4, leaves niton of atomic weight 222. It has been calculated that radium disintegrates at such rate that the time required for one-half of any given quantity to break up into other elements is about 1,670 years, and that the total heat development of 1 grm. is about 25·5 calories per hour.

It has been suggested that radium offers an explanation of the formation of the Aurora Borealis or Northern Lights (J. E. Gendreau).

The penetrating radium rays are capable of bringing about many chemical changes, among which may be instanced their action on toluene, resulting in the production of benzaldehyde and benzoic acid. (See a survey of the world's deposits of radium (*C.T.J.*, 1929, **84,** 421); "Radium Industry," by C. E. S. Phillips (*C.T.J.*, 1925, **76,** 259); Meso-Thorium and X-rays.)

RAFFIA—See Raphia.

RAFFINOSE (**Melitriose**) ($C_{18}H_{32}O_{16},5H_2O$)—A soluble carbohydrate, very like cane sugar, but tasteless, found in the sugar-beet and its molasses, and obtainable from cotton-seed meal and other sources. It is dextro-rotatory and splits up into other sugar-like bodies upon inversion, the action of acids producing galactose, fructose, and glucose. (See *J.C.S.*, 1923, **123,** 3125, and 1927, p. 1527.)

RAGSTONE—An impure limestone.

RAIL CHARGES and Chemical Industry—See J. W. Parker (*Ind. Chem.*, 1927, iii., 101).

RAISIN-SEED OIL—See Grape-seed Oil.

RAMAN EFFECT—The general theory is briefly reviewed by L. E. Howlett (*B.C.A.*, 1931, A, 667); see also *Chem. Soc. Annual Report,* 1929, **26,** 16; S. Bhagavantam (*Indian J. Physics.*, 1930, **5,** 237); and E. H. Kennard (*B.C.A.*, 1931, A, 21).

RAMIE (**Rhea Ramie,** or **Chinese Grass**)—The fibre of several varieties of the genus *Bœhmeria* (N.O. Urticaceæ), or the Rhea of Assam, now grown in India and Italy, and said to be nearly three times stronger than Russian hemp. It is obtained by the decortication and degumming of the white-leaved *Bœhmeria nivea* and the green-leaved *B. tenacissima.* The decorticated fibre yields 5·63 per cent. ash, contains 10·15 per cent. water, and yields a water extract of 10·34 per cent. It contains 0·59 per cent. fat and wax, about 66 per cent. cellulose, and 12·70 per cent. pectin bodies, while the degummed product, which is obtained by digestion of the bast fibres in water, is practically pure cellulose, identical in composition with bleached cotton and linen, and can be dyed in common. It is used in China for making mats and sails; in Saxony for making tapestry, tablecloths, damasks, etc.; and is the principal yarn from which gas-mantle fabrics are knitted and woven. It is used in this country in paper, rope, and cord making, also in the textile industry and silk decoration.

RANCIDITY—See Fats, p. 338.

RAOULT'S LAW—See Freezing-Points.

RAPE-SEED OIL (Colza Oil)—A dark, non-drying, yellowish, fatty oil of unpleasant odour extracted by pressure from rape-seed, a plant of the cabbage tribe of the genus *Brassica* (*Brassica napus, campestris*, etc., N.O. Cruciferæ). The best rape-seed comes from Shanghai and Hankow in a number of varieties, and a considerable quantity is raised in India, China, and Japan. It yields from 33 to 45 per cent. of oil, soluble in alcohol, carbon disulphide, ether, and chloroform; of solidifying point, $-2°$ to $-10°$ C.; sp. gr., 0·9132 to 0·9168; sap. v., 170 to 179; ref. ind., 1·4725; and i.v., 94 to 104. It contains about 33 per cent. linolein, 10 per cent. saturated glycerides, the remainder being erucic and rapinic acids (about 44 per cent.). The composition of German rape oil is given by Täufel and Bauschinger (*Analyst*, 1929, **54,** 187) as follows: Saturated fatty acids, 0·8; erucic acid, 43·5; oleic acid, 37·8; linolic acid, 10·6; linolenic acid, 3·5; unsaponifiable matter, 1·0; and glyceryl residue (as C_3H_2), 3·8 per cent. It can be "blown" like linseed oil, and is used to some extent for illuminating purposes, but chiefly for oiling woollen stuffs and as a lubricant. The pressed cake is of value as a feeding stuff. It has been reported that a liquid of the same nature as petrol is obtained by the dehydrating action of molten zinc chloride upon rape-seed oil at 350° to 400° C.

RAPHIA—A fibre obtained by stripping the bast from the leaf of the palms that give piassava; it can be dyed like straw and is used in making mats and basket ware and for tying up plants. (See Piassava.)

"RASORITE"—An American mineral hydrated sodium borate made in the Kramer district near California.

"RAYON"—Name used for certain silk substitutes, but not inclusive of all varieties. It applies to viscose silk, but not to cellulose acetate and other synthetic fibres.

RAYS—See *Molecular Rays*, by R. G. J. Fraser (Cambridge Univ. Press); Neutrons, Radiation, Radio-activity, Wave Lengths, and X Rays.

REACTIONS—See Chemical Interactions and Gas Reactions.

REAGENTS—Solutions used for testing purposes—that is to say, bringing about chemical reactions—in qualitative analysis, comprising strong hydrochloric, nitric, and sulphuric acids; dilute solutions of the same acids (of strength 1 part to 4 parts water); and various salts containing about 5 per cent. of the respective substances, dissolved in water.

For use in the practice of volumetric analyses, solutions of known strength, or so-called "standard solutions," are employed, the quantities of the constituents bearing the same relation to each other as the numbers which express their chemical equivalents. When they are made of such strengths that a litre (1,000 c.c.) contains equivalent weights in grammes—for example, 36·5 grammes (NaCl) in 1,000 c.c. —they are termed "normal standard solutions." A storage and de-

REAGENTS (*Continued*)—
livery apparatus for certain corrosive reagents is described by G. Middleton (*Analyst*, 1931, **56,** 236). (See Volumetric Analyses.)

REALGAR (As_2S_2)—See Arsenic.

REAUMUR—See Heat, p. 438.

RECORDERS—Appliances for recording rate of flow of steam, water, gas, and oil, together with pressure, temperature, sp. gr., draught, etc.

The "Ranarex CO_2 recorder" is a device for indicating and recording the carbon dioxide in flue gases and the exhaust gases of motor-car engines, depending upon the difference of sp. gr. of the flue gases and the air in the boiler house.

The "Cambridge Electrical SO_2 recorder" is an apparatus for measuring the percentage of sulphur dioxide in connection with various chemical processes. The Cambridge Company also make a recorder which gives readings of both temperature and pressure on one chart. (See *Ind. Chem.*, 1925, i., 336; J. Grant on "The Control of Flue Gases by means of Carbon Dioxide Recorders" (*Ibid.*, 1926, ii., 433); C. Morton on "An Automatic *p*H Recorder" (*J.S.C.I.*, 1931, **50,** 436 T); "Automatic Recorder for Sulphur Acids in Flue Gases," by Fox and Groves (*J.S.C.I.*, 1932, **51,** 7 T); Fuel Research Technical Paper No. 27 on "Measurement of a Rapidly Fluctuating Flow of Gas," by King and Williams (H.M. Stationery Office); Densimeter, Meters, and Rota-Meters.)

RECTIFICATION—Purification of a volatile liquid by fractional distillation; for example, a second distillation (redistillation) of alcoholic liquids is an act of rectification from associated substances left in the retort. An improved laboratory rectifying column is described by M. J. Marshall (*Ind. Eng. Chem.*, December, 1928). (See Distillation.)

RED ANTIMONY—See Antimony and Kermisite.

RED CURRANT SEED OIL—See A. Jermstad (*Analyst*, 1931, **56,** 324).

RED LEAD (**Minium**)—See Lead Compounds.

RED LIQUOR—See Aluminium Compounds (Acetate, p. 40).

RED OIL—See Oleic Acid.

RED OXIDE—See Iron Compounds (Ferric Oxide), Ochre, and Reddle.

RED PRUSSIATE—Potassium and sodium ferrocyanides respectively.

REDDLE (**Ruddle**)—An earthy, ochreous ore of iron (ferric oxide) associated with clay, chalk, or other mineral matter, from hæmatite deposits found in some English counties and elsewhere, and used by farmers for making a red paste to mark sheep.

"REDMANOL"—A resin of the phenol-formaldehyde condensation type.

REDONDA PHOSPHATES—Natural phosphates of iron and aluminium found in the islands of Redonda and Alta Vela.

REDRUTHITE—Mineral copper sulphide (Cu_2S), of crystal system, No. 4, and sp. gr. 5·5.

REDUCING AGENTS—Substances are said to act as reducing agents, as when, for example, oxygen is removed in some degree from an oxide

REDUCING AGENTS (*Continued*)—
or certain ores by the agency of hydrogen or carbon, or by the use of hydrocarbons or that of producer gas at an appropriate temperature for similar processes. Red lead is reduced to metallic lead by strongly heating it with charcoal. Ferric chloride ($FeCl_3$) can be easily reduced to the lower ferrous chloride ($FeCl_2$). Reduction can be effected by the addition of hydrogen to an organic compound through the agency of sodium amalgam. Members of the sugar series can be reduced by the action of aluminium amalgam, and the manufacture of aniline is carried out by a reducing process. (See Aniline.)

REDUCTION—See Reducing Agents.

REFLECTION—See Light, p. 534.

REFLUX CONDENSER—See Dephlegmate, Extraction, Percolation, and Rectification.

REFRACTION—The effect which is produced when a ray of light passes from one medium to another, making a body partially immersed in water, for example, look as if it were broken. (See Light and Refractometers.)

REFRACTIVE INDEX (**Ref. Ind.**) is a constant at a defined temperature —that is, the ratio of the sine of the angle of an incident ray to that of the angle of the refracted ray. (See A. Mayrhofer, *Analyst*, 1932, **57**, 65.)

REFRACTOMETERS—Instruments for measuring the velocity of propagation of light in a substance, this velocity being inversely proportional to the refractive index of substances. The refractive index is constant for every pure substance under standardized conditions of temperature and pressure.

There are refractometers for various purposes, one of the best for purely scientific work being the "Pulfrich," used for investigating optical glasses, etc. The so-called "Butyro" and "Oleo" refractometers, such as the "Abbé Zeiss" and "Féry" instruments, are largely used for butter, oils, and fats; while other instruments are the "Abbé" (which is used for liquids and also utilized in the determination of melting-points), the "Jamin," and the "Rayleigh." The "Askania" immersion refractometer is described by A. Doliner (*B.C.A.*, 1930, B, 1095).

REFRACTORIES are substances difficult to fuse, including materials employed in the construction of furnaces, ovens, kilns, retort settings, furnace hearths, stoves, crucibles, etc., affording resistance to heat, abrasion, strain, and the action of gases or other chemical compounds to which they are exposed in use.

Some refractories melting at about 1,800° C. are made by heating mixtures of kaolin and alumina, or bauxite and fire-clay.

Clays, fire-clays, and silica in the forms of flint, dinas rock, quartz, sandstone, and ganister are described as acid refractories, containing as they do silicic acid alone or in combination (as in the clays) with alumina; while chromite (natural chromate of iron), graphite, and

REFRACTORIES (*Continued*)—

plumbago are neutral in character, and bauxite, lime, magnesia, and zirconia are examples of so-called basic refractories.

Silica and clay are also used as fluxes, so as to produce more or less fluid siliceous slags for collection of the impurities contained in ores and from which they can be tapped off, while other compounds are sometimes added to increase the fluidity or to reduce the melting-point of the slag, such as fluorspar, borax, common salt, and nitre.

In salt glaze kilns the temperature generally ranges from 1,200° to 1,300° C., and occasionally reaches 1,370° C.

Fire-clay, being acidic in character, is destroyed when heated with bases such as lime; and magnesia, being basic, is destroyed when heated with an acid refractory such as clay.

Mica, talc, alumina, and carborundum are other refractories.

The mineral chromite is largely used in the manufacture of bricks for lining steel and copper smelting furnaces. These usually contain about 33 per cent. chromic oxide, with less than 6 per cent. of silica, the bricks being compounded by mixing the powdered ore with water and a binding material (such as tar) into paste form, followed by moulding, drying, and burning up to 1,460° C. in kilns.

Refractory mortars and cements employed for joining, patching, or binding, and as washes over surfaces, are sometimes made of corresponding materials—viz., silica rock, fire-clay, ganister, and silica brick ("grog")—but slightly more fusible than those to be treated, so that a vitrified bond is formed upon the application of strong heat. The chief bonding agents are ball-clay, lime, Portland cement, sodium silicate, and ground glass.

Zirkite cement consists wholly of zirconia, finely ground and made into a paste with water, while silica bricks are generally used in the construction of electric furnaces.

In his work on *Refractories*, by A. B. Searle, it is stated that fire-bricks heated in a darkened chamber (as in a kiln) exhibit the appearances noted below at various given temperatures:

Just-visible red	500° to 650° C.
Cherry red	850° to 900° C.
Bright red	1,000° C.
Orange	1,100° C.
Yellow	1,200° C.
White	1,500° C.

and that they begin to lose their shape when the temperature reaches to from 1,600° to 1,800° C.

"Spalling" of fire-brick is defined as fracture or disintegration caused by rapid changes in temperature. (See Heindl and Pendergast, *B.C.A.*, 1929, B, 979.)

A German method of preparing ordinary bricks, so as to give them a refractory character, consists in coating them with a mixture of 75 per cent. carborundum and 25 per cent. sodium silicate, and after drying, slowly heating, and "burning in" the mixture.

REFRACTORIES (*Continued*)—

The sensitiveness of a fire-clay to load is the greater, the greater the alumina content of the clay, and conversely it decreases as the silica content increases. The loss of mechanical strength of coarse-grained silica bricks at high temperatures is much less than that of fire-clay bricks. All refractory products become more or less plastic beyond 1,200° C., no abrupt rupture then taking place. Physical tests, especially the heat conductivity, are of great importance in the examination of refractories.

A silica brick containing over 97 per cent. silica is stated to be universally used in the United States on account of its great resistance to high temperatures, so that from 2,350° to 2,550° F. can be used, and even 2,700° to 2,900° F. for limited periods, this being some 400° to 475° F. higher than that which can be employed with ordinary fire-bricks. These bricks exhibit greater conductivity at high temperatures, and are more resistant to the corrosive action of salt.

Electrically sintered magnesite, containing 95 per cent. MgO and less than 1 per cent. iron oxide, as produced in the U.S.A., is non-contractile and particularly resistant to high temperatures (having a melting-point of about 2,600° C.), thus making it valuable for lining metallurgical furnaces, etc.

(See "Silica Refractories," by P. B. Robinson (*J.S.C.I.*, 1926, **45,** 29 T); "The Drying and Burning of Refractory Materials," by West and Fagan (*Trans. Ceramic Soc.*, 1926, vol. 25, pp. 500-518), and abstract (*Chem. and Ind.*, 1926, **45,** 720); "The Selection of Refractory Materials used in Industrial Chemistry" (A. B. Searle, *Ind. Chem.*, 1926, ii., 51); "The Requirements of Modern Refractory Materials," by A. T. Green (*Ibid.*, 1928, iv., 484); "Refractories in the Gas Industry," by Smith and Spiers (*Chem. and Ind.*, 1928, **47,** 1278); "Some Industrial Tests on Refractory Materials," by W. H. Simmons (*Ind. Chem.*, 1929, v., 338); "High Refractory Compositions employed in the Manufacture of Laboratory Utensils," by R. Schwarz (*Chem. and Ind.*, 1930, **49,** 271); "Works Tests on Refractories and Service Conditions," by R. J. Sarjant (*Chem. and Ind.*, 1930, **49,** 992); "Refractories in the Carbonizing Industries," by T. F. E. Rhead (*Chem. and Ind.*, 1931, **50,** 564); "Protective Coatings for Interiors of Furnaces, etc." (*C.T.J.*, 1932, **90,** 8); *A Comprehensive Treatise on Refractories,* by A. B. Searle (C. Griffin and Co.); Clays, Porcelain, Saggars, and "Sillimanite.")

REFRIGERATION—There are processes for refrigerating perishable and other articles, based upon the cooling which is produced by causing volatile liquids like strong ammonia and liquefied carbon dioxide to assume the vaporous state. This change of state involves the absorption of heat, and can thus be made available for the construction of cooling chambers in which foods, etc., are kept. The machinery involved in mechanical refrigeration is of two classes—viz., compression and absorption—the former employing carbon dioxide, sulphur dioxide, ammonia gas, or the vapour of ethyl chloride, while absorption machines depend upon the use of ammonia.

REFRIGERATION (*Continued*)—

A kilogram of liquid ammonia evaporated at $-10°$ C. absorbs 322·3 calories; in other words, that amount of heat is rendered latent by the energy required to change its molecular state. The refrigerator styled "Electrolux," which works without any mechanical moving parts, using ammonia for evaporation, is described in *C.T.J.*, 1926, **78,** 288, and the *Ind. Chem.*, 1927, iii., 264. (See also *Chem. and Ind.*, 1926, **45,** 770.)

A new refrigerant of non-toxic character which it is thought may be useful for the cooling of sleeping and other rooms is dichloro-difluoromethane (CF_2Cl_2), prepared from antimony trifluoride and carbon tetrachloride. (See Midgley and Henne, *Ind. Eng. Chem.*, May, 1930, **22,** 542.)

It is stated that cork slab stands first amongst insulators in refrigeration technique, while other combinations are made from cork and peat encased with tar. According to the Report respecting heat insulators (Food Investigation Special Report No. 35, H.M. Stationery Office), the conclusion is reached that the thermal conductivity of insulating material through the temperature range ordinarily observed in cold storage is represented by 0·29 B.Th.U. per square foot per hour per 1 inch thickness for 1° F. difference of temperature between the faces, and that most samples of good slab cork fall little short of this.

Gard and Robinson, in a paper on "The Insulation of Heated and Cooled Surfaces," have given a selection of insulating materials classified according to the temperature range, showing their outstanding advantages and disadvantages as interpreted by them. (See *C.T.J.*, 1930, **86,** 330, and "Cell Concrete.")

The opinion has been expressed by J. S. F. Gard that compressed cork in sheet or pipe sections is the best material for insulation for low temperature ranges, and a blended mixture of basic magnesium carbonate and asbestos for medium temperature ranges. Glass wool, slag wool, diatomaceous earth, pumice, and cotton waste are also used.

As to the preservation of meat and fish, it has been shown that, by sufficiently rapid cooling to a temperature that corresponds to the eutectic of a saline solution, the separation of frozen water as a visible phase is avoided, so that, upon thawing, the system returns to its original state; otherwise the mass, when thawing, is liable to lose a certain amount of nutritive material, which drains away with the water.

The most important factor concerning the preservation of food is temperature, research having shown that in respect of living systems such as fruit and eggs it is best to employ one slightly above freezing-point, whereas with dead foodstuffs such as meat the chief aim is to restrict the action of moulds and bacteria and to control the extent of structural change. Temperature, humidity, and the composition of the air have all to be controlled. (See *Chem. and Ind.*, 1929, **48,** 485/6.)

Solid carbon dioxide has all the desirable properties of ice, and twice its sp. gr., and when it can be used, has great advantages over ice, 100 lbs. doing the work of nearly a ton of ice. (See description of dry ice, p. 146.)

REFRIGERATION (*Continued*)—

Processes of refrigeration are often used in chemical investigations, and there are many kinds available. Boiling methyl chloride as a frigorific gives a temperature of – 23° C., and solid carbon dioxide in ether or alcohol gives one of – 75° C., while liquefied air has given the means of liquefying hydrogen and helium. One of the simplest freezing mixtures is a mixture of ammonium nitrate (NH_4NO_3) and water in equal parts, the dissolving of the salt causing a drop in temperature to 4° F. (– 15·56° C.). Another one consists of equal parts of sodium sulphate and commercial hydrochloric acid, which gives a temperature of + 3° F. (– 16·11° C.). By the use of a mixture of 2 parts snow or pounded ice and 1 part salt a steady low temperature of – 4° F. (– 20° C.) can be maintained; while one of 2 parts snow and 3 parts crystallized calcium chloride ($CaCl_2$) will bring the temperature down to – 50° F. (– 45·55° C.). According to a recent German patent (W. Kasch, 463,792), a mixture of 100 parts ammonium chloride, 150 parts of anhydrous sodium carbonate, and 300 parts water, gives a temperature drop of 31° C.

(See T. Moran on "Rapid Freezing" (*J.S.C.I.*, 1932, **51**, 16 T and 21 T); H. C. Ross on "Meat Freezing Industries and their Chemistry" (*Chem. and Ind.*, 1926, **45**, 455); T. Moran on "Low-Temperature Preservation of Foodstuffs" (*J.S.C.I.*, 1929, **48**, 245 T, and *Chem. and Ind.*, 1932, **51**, 84); E. W. Lewis on "Mechanical Refrigeration" (*Chem. and Ind.*, 1926, **45**, 771); H. M. Dunkerley on "Refrigeration Plant" (*C.T.J.*, 1926, **79**, 703 and 715); G. W. Daniels (*Ibid.*, 1927, **81**, 593); note on "Glass Silk," a new insulating material (*C.T.J.*, 1931, **89**, 254); an article on refrigeration (*The Times* of August 11, 1930); *Refrigeration in the Chemical Industry*, by G. W. Daniels (Chapman and Hall, Ltd.); Eutectic and Heat.)

REFUSE—See Effluents and Waste.

REGELATION—The freezing of water anew, brought about by reduction of pressure, the m.p. of ice (0° C. under pressure of 1 atm.) being affected by the alteration of pressure to a slight extent; thus, two pieces of ice, when rubbed together, melt at the surfaces and form into one mass upon relieving the pressure.

REGULUS METAL—Metallic alloys reduced to a crude state from oxides or other compounds by fluxing with reducing agents. Four types are recognized by the B.E.S.A. (See Ores.)

REICHERT-WOLLNY VALUE—See Fats.

REINSCH'S TEST FOR ARSENIC is based upon the fact that if a clean strip of copper be boiled in an acidified arsenical solution, a deposit of copper arsenide (Cu_5As_2) forms on the surface.

RELATIVITY—See article by Einstein (*The Times*, February 4 and 5, 1929); L. L. Whyte's summary (*The Times*, January 31, 1929; *The Times*, May 25, 1931); *Einstein's Theory*, by J. Rice (Longmans, Green and Co., London); and Light.

RENNET (RENNIN)—An infusion of the inner membrane of the fourth stomach of the calf, soluble in salt water and used for coagulating milk in cheese-making. This coagulation is due to the action of an enzyme (contained in the rennet) of a class different from the enzymes which act by hydrolysis or oxidation, and is regarded by some as a decomposition product of protein of the acid albumin class. It readily diffuses through a parchment membrane and is not precipitated by heat. Several methods of preparing it are given in Jean Effront's *Bio-chemical Catalysts* (Chapman and Hall, Ltd., London).

RESCUE APPARATUS—See Safety (Industrial).

RESINATES—Compounds of the acid constituents of resin. The alkaline resinates known as "resin soaps" are largely used in sizing paper; for incorporation with ordinary soaps; the preparation of inks, paints, dopes; making polishes for wood and leather; as lubricants, and as substitutes for linseed oil in respect of certain applications. Resinate of sodium is made by digesting resin up to 47 per cent. in hot caustic soda solution, the product being a viscid cream or paste, as desired, which is miscible with water. Other resinates are obtained by chemical reaction between such solutions and metallic salts. The partial (fused) resinates obtained by fusion of resin with metallic salts or oxides are extensively employed in compounding printing inks, also as siccatives for the drying of oils (owing to their solubility in linseed oil at comparatively low temperatures) instead of heating the oils at 180° with the oxides of lead or manganese. Those made by fusion always contain some free resin, and the use of such acid resinates is apt to lead to difficulties in the manufacture of paints, lacquers, and dopes when mixed with mineral colours, particularly those of zinc and lead, whereas with the true resinates these difficulties are not encountered.

The fused resinates are not completely dissolved by turpentine, tetraline and some other solvents, but the partial solutions are used to some extent as liquid driers for paints and varnishes.

"RESINITE" is one of the so-called synthetic resins, made by action of formaldehyde upon phenol. (See Synthetic Resins, p. 430.)

RESINOIDS—See Gums and Resins (Synthetic Resins).

RESORCINOL (RESORCIN) ($C_6H_6O_2$ or $C_6H_4(OH)_2$), m.p. 119° C., b.p. 276° C., is a white crystalline dihydric phenol of antiseptic character which can be prepared, among other ways, from many resins such as galbanum, and asafœtida by fusion with caustic potash. It is soluble in water, alcohol, and ether; exhibits a therapeutical action mildly resembling that of phenol, and is the basis of a number of dyes—nitrous acid, for example, transforms it into an azo-dye. It can also be used as a solvent in printing pastes containing basic dyestuffs, thus dispensing with the usual steaming process.

RESPIRATION is essentially a chemical process whereby the blood is purified by absorption of oxygen from the air breathed into the lungs; nitrogen, carbon dioxide, and aqueous vapour being exhaled. The

RESPIRATION (*Continued*)—
exhaled breath contains about 4·4 per cent. of carbon dioxide and 16·4 per cent. oxygen as compared with 0·4 per cent. of the former and 20·96 per cent. of the last-named substance (contained in the inhaled air), together with moisture, traces of ammonia, and some organic matters that make overcrowded or ill-ventilated rooms unpleasant and unhealthy. (See Ventilation.)

The inhaled oxygen of the air enters into a loose combination with the hæmoglobin of the blood corpuscles and is thus carried to all parts of the living tissues, which in their turn give up carbon dioxide, water, urea, and other excrementitious products which are carried away in the breath and urine. It has been estimated that 1,000 c.c. of healthy human blood may contain a maximum of 240 c.c. oxygen. (See Hæmatine.)

When air contains from 2·5 to 3 per cent. carbon dioxide, breathing is adversely affected, and becomes distressful when 4 per cent. is reached, while with a content of 5 per cent. distress becomes acute.

The water given off in the exhaled breath in twenty-four hours has been estimated at 311 grms., or nearly 11 ozs., and the carbon (as carbon dioxide) at from 7·144 to 11·7 ozs. (See H. Wieland on "Biological Oxidation" (*Chem. and Ind.*, 1931, **50**, 220).)

RESPIRATORS—See Gassing.

RETINE ($C_{18}H_{18}$)—A hydrocarbon (methyl-isopropyl-phenanthrene) accompanying pyrene, etc., in the coal-tar distillate which comes over above 360° C., and used by a Swedish process as a source of dyestuffs. (See Pyrene.)

RETORTS (STILLS)—Apparatus made of glass, earthenware, iron, steel, platinum, etc. (according to the chemical characters of the materials to be dealt with), variously used for the separation of the more volatile parts of liquid or solid mixtures and for "cracking" or so-called destructive distillation of tar, petroleum, and other substances, etc.

The retorts for roasting coal in the process of gas-making and other industrial operations are constructed on the same principle as laboratory retorts, coupled with cooling arrangements (condensers) for condensing the distillates. The Fuel Research Board's Report for the year ended March 31, 1930 (H.M. Stationery Office), points to a saving of heat effected by the particular setting of vertical retorts. A laboratory double-flask distilling apparatus is described and illustrated in the *Ind. Chem.*, 1925, i., 110. (See also Distillation.)

RETTING—Soaking, macerating, or wetting. (See Flax.)

REVERBERATORY FURNACE—See Furnaces.

REVERSIBLE REACTIONS—See Chemical Interactions (p. 175).

RHAMNOSE (Iso-dulcite) ($C_6H_{12}O_5.H_2O$)—A colourless crystalline carbohydrate or sugar-like body (methyl-pentose), m.p. 93° C., obtained from several glucosides by hydrolysis; for example, quercitrin extract

RHAMNOSE (*Continued*)—

(from *Rhamnus tinctoria*) and frangulin (from *Rhamnus frangula*) yield rhamnose. (See Quercitrin and Persian Berries.)

RHAMNOSIDES—Glucosides which yield rhamnose upon hydrolysis.

RHATANY ROOT (Krameria)—The dried root of *Krameria trianda* or *K. argentea* (from Peru, Bolivia, and Brazil), containing from 8 to 20 per cent. of a tanning material. It has powerful astringent properties, is used in cases of diarrhœa, etc. (in which its astringent character is of value), and is sometimes incorporated in tooth powders.

RHENANIA PHOSPHATE—See Leucite.

RHENIUM (Re) (Dvi-Manganese)—An element of atomic number 75; atomic weight previously given as 188·7, but recently re-determined by Honisschmid and Sachtleben as 186·31 ± 0·02 (*B.C.A.*, 1930, A, 1338); said to consist of two isotopes 185 and 187 (F. W. Aston, *Nature*, April 18, 1931). It is most abundant in certain molybdenum ores, frequently present in manganese preparations, and obtainable as a heavy grey powder by reduction of the sulphide in hydrogen; inflames at 300° C. in oxygen gas, forming a volatile greenish-white oxide (Re_2O_7) of m.p. 26° to 30° C. It is made commercially as potassium per-rhenate, containing 64·6 rhenium, from which compound the oxide can be obtained. (See *J.C.S.*, 1925, Abs. Vol. 2, p. 939; W. Noddack (*B.C.A.*, 1928, A, 1334); Frau I. Noddack (*Ibid.*, 1929, A, 21); I. Noddack and W. Noddack (*Ibid.*, 1929, A, 411 and A, 1408, and *Ibid.*, 1931, A, 583 and A, 707); W. Feit on "Technical Preparation of Rhenium" (*B.C.A.*, 1930, B, 822); C. Agte (with others) on "The Physical and Chemical Properties of Rhenium" (*B.C.A.*, 1931,A, 448); Briscoe, Robinson, and Stoddart on "Rhenium Sulphides and Selenides" (*J.C.S.*, 1931, p. 1439); and I. G. F. Druce on "The Technical Preparation of Dvi-Manganese" (*Ind. Chem.*, 1931, vii., 75).

RHEOSTATS—See Electricity, p. 298.

RHIZOME—Underground stems or rootstock.

RHODAMINES—A series of xanthene dye-bases related to fluoresceïn, being colourless bodies of which the salts, such as the sulphate, are red.

RHODINOL ($C_{10}H_{19}OH$)—An alcoholic body occurring in the essences of rose and geranium. It can be prepared synthetically from β-geraniol. (See Grignard and Escourrow, *J.C.S. Abs.*, 1925, I., 772.)

RHODIUM (Rh) **and its Compounds**—Atomic weight, 102·9; atomic number, 45; sp. gr., 12·47 in vacuo at 0°/4°. A metallic element found in platinum ores to the extent of about ½ per cent., and belonging to the same group. It is white, lustrous, has a high m.p. (above that of platinum—about 1,960° C.), and is used in the construction of electrical pyrometers. Several oxides are known—viz., Rh_2O, RhO, Rh_2O_3, and RhO_2, and its salts include three chlorides ($RhCl$, $RhCl_2$, and Rh_2Cl_6), two sulphides (RhS and Rh_2S_3), also a sulphate corresponding to the sesquioxide ($Rh_2(SO_4)_3$). According to a recent paper, the

RHODIUM (*Continued*)—
m.p. of the metal is 1985 ± 10°, *d* 12·41, and Brinell hardness 101 (W. H. Swanger, *B.C.A.*, 1930, A, 530).

RHODIUM (**Rosewood**)—The wood of *Convolvulus scoparius* and *C. floridus*, etc. (from Canary Islands and West Indies), containing an oil (0·04 per cent.) used in perfumery and for baiting the fox, etc. The wood is also used by cabinet-makers and pen manufacturers.

RHUBARB (**Rheum**)—The dried rhizome of *Rheum officinale*, of which many species grow wild on the high lands of Central and Western China and Thibet, while others are cultivated; used for its purgative properties. The juice of the stems contains oxalic, malic, and citric acids, the oxalic acid being in combination as soluble potassium binoxalate (KHC_2O_4), to which its poisonous qualities are due. Rhubarb root contains chrysophanic acid and other substances. English garden varieties (*Rheum undulatum* and *Rh. hybridum*) are used as food, while the rhizome from the English-grown *Rh. officinale* is practically identical with the Chinese plant, and both are used in medicine.

RHUS (**Sumach**)—There are many species rich in tannic acid. (See Sumac.)

RICE—A well-known grain (*Oryza sativa*), being the only important species of a genus of grasses (of which the chief constituent is starch) largely grown in Asia, South America, and the U.S.A., the chief producing countries being India and China. The sp. gr. of rice is about 1·43 to 1·46, and the flour contains from 73 to 78 per cent. starch, associated with fat varying from 0·5 to 1 per cent., albuminoids (chiefly protein) from 7 to 8·5 per cent., water about 13 per cent., and small proportions of mineral and other substances. Polishing decreases the nutritive properties of rice. The polishings contain oil; n_D^{25} 1·4690, sap. v. 185·3, i.v. (Hanus) 99·9, Reichert-Meissl v. 0·3, Polenski v. 0·3, and acid v. 73·7 (see G. S. Jamieson, *Analyst*, 1926, **51**, 583), and the material is usually sold as a fertilizer or feeding-stuff, while rice hulls are now also used as a source of cellulose. The manufacture of rice starch is described by A. E. Williams (*Ind. Chem.*, 1930, vi., 387); the curative activity of rice polishings by B. C. Jansen (with others) (*Chem. and Ind.*, 1930, **49**, 990); and the utilization of rice husks for various purposes is suggested by L. B. de Mongeot (*B.C.A.*, 1930, B, 528).

Analyses of rice from the Philippine Islands and the U.S.A. respectively have been published as follows:

	Philippines.	United States.
Weight of 100 kernels (in grms.) ..	1·97	2·46
Moisture (per cent.)	12·26	11·88
Protein ,, ...	7·93	8·02
Ether extract (per cent.)	2·03	1·96
Crude fibre ,, ...	1·18	0·93
Other carbohydrates (per cent.) ..	75·89	76·05
Ash ,, ..	1·46	1·15
Phosphorus pentoxide ,, ..	0·75	0·40

RICE (*Continued*)—

Rice bran contains about 13 to 15 per cent. fat, and owing to this and its porosity it becomes rancid by storage. Later analyses of two samples of rice bran are given by S. Fujita (*B.C.A.*, 1929, B, 157). The wax in rice polishings is alleged to be melissyl cerotate (see U. Tange, *B.C.A.*, 1931, B, 125). (See Starch and Vitamins, p. 960.)

RICIN (**Ricinine**)—A nitrogenous substance (perhaps $C_{12}H_{12}N_2O_2$) contained in all organs of the castor-oil plant; in seeds about 0·15 per cent., and in leaves about 1·37 per cent.

RICINOLEIC ACID ($C_{18}H_{34}O_3$, or $C_{17}H_{32}(OH)COOH$)—The glyceride of this fatty acid (triricinolein) makes up some 82 per cent. of castor oil, and occurs also in curcas oil. The acid is yellowish, thick, m.p. 3° C., sp. gr. 0·945; i.v. 85·39; acid v. 188·1; soluble in alcohol, ether, etc.; resembles oleic acid in properties, and is used in soap-making, manufacture of Turkey-red oils, and dressing of textiles. (See Castor Oil.)

"RIMU" OIL—From the leaves of the red pine, *Dacrydium cupressinum* (Salander), which abounds in the forests of New Zealand; contains as its chief constituent a solid crystalline diterpene ($C_{20}H_{32}$), melting at 55·5°.

RINGS—Collections of atoms arranged in ring form, such as the benzene ring. The proposed international rules for numbering organic ring systems are the subject of a leaflet by Austin M. Patterson (issued with the *J.C.S.* for March, 1925), and passed provisionally by the Committee on Organic Nomenclature of the International Union of Pure and Applied Chemistry. Communications on this subject should be made to A. J. Greenaway, The Orchard, Chertsey, Surrey. (See also Benzene Ring, Chains, Cyclic, Heterocyclic, and Homocyclic.)

"RINSO"—A very soluble washing powder.

RITHA—An Indian soap substitute, consisting of an alkaline deposit found on certain waste lands. (See Sajji.)

RIVER POLLUTION PREVENTION—See Water.

ROAD-MAKING—The B.E.S.A. have published specifications of Tars No. 1 and No. 2 for road-making, also specifications for asphalt roads which have been approved by the Ministry of Transport. The "Slippery Roads Committee of the National Horse Association" (12, Hanover Square, London, W. 1) have issued a report advocating the use of better and larger-sized grit when tar-spraying takes place. Complaints have been made where limestone has been used in the surface coat and where limestone, dirty gravel, or sand have been employed after tar-spraying, while, on the other hand, an admixture of about 30 per cent. of ¾-in. granite chippings or clean gravel is strongly advocated. The prevalent belief is that British prepared tar is superior to the use of asphalts and bitumins for the greater part of road-making in this country, both technically and financially. Tar provides a surface which gives a grip to motor tyres, whereas the other named materials become smooth and slippery with wear.

References to the uses of silicate of sodium solution as a binding dressing for the surfaces of concrete roads and of asphaltic or bituminous

ROAD-MAKING (*Continued*)—
emulsions for the surfaces of tarred or asphaltic roads are given under the headings of Asphalt and Sodium (Silicate).

See J. A. Butterfield on "Road-Surfacing Materials" (*J.S.C.I.*, 1928, **47**, 293 T); F. Levy (*Chem. and Ind.*, 1928, **47**, 1320); W. E. Cone on "Road Tar and its Uses in Great Britain" (*Chem. and Ind.*, 1928, **47**, 1048); M. Leduc on "Bituminous Road-Making" (*Chem. and Ind.*, 1932, **51**, 53); D. M. Wilson on "Asphalt Paving Materials" (*Chem. and Ind.*, 1932, **51**, 61); First Report of Technical Committee, Transport, Roads Department (H.M. Stationery Office); *Road-Making*, by Bradley and Hancock (The Contractors' Record, Ltd., 327, High Holborn, London); Asphalt, Concrete, "Fullersite," and Tar, p. 897.

ROASTING (Ores)—See Furnaces, Pyrites, and Ores.

ROBURITE—See Explosives.

ROCHELLE SALT ($KNaC_4H_4O_6,4H_2O$)—A double tartrate of potassium and sodium, being a colourless crystalline compound, soluble in water, used in the preparation of Seidlitz powders and certain baking-powders; also that of tartaric acid and cream of tartar by treatment with calcium carbonate. It loses its water of crystallization at 215° C.

ROCK CRYSTAL—See Silicon.

ROCK PHOSPHATES—See Phosphates, Phosphorus, and Iron (Slag).

ROCK SALT—See Sodium.

ROCKS—See *The Chemical Analysis of Rocks*, by H. S. Washington, 4th edition (John Wiley and Sons, Inc., N.Y.).

ROMAN ALUM—See Aluminium (Alums), p. 39.

ROMAN CEMENT—A form of hydraulic cement, in making which septarian nodules are employed. (See Cement and Septaria.)

"RONGALITE"—The name given to certain German reducing agents used in the dyestuffs and dyeing industries, said to be sodium formaldehyde-sulphoxylate and zinc formaldehyde-sulphoxylate, the last named being used for "stripping." (See "Zinc Formosul.")

RÖNTGEN RAYS—See X Rays.

ROPINESS (of Beer, Milk, Bread, etc.)—A defect due to biological changes induced by certain micro-organisms of the *B. mesentericus* group, such as *Acetobacter R.* It can be inhibited by lactic acid and acid potassium and calcium phosphates used in sufficient amount, while low temperature, ventilation, and cleanliness are the best preventives. (See Fisher and Halton (*B.C.A.*, 1928, B, 622); Amos and Kent-Jones on "Rope" (*Analyst*, 1931, **56**, 572); and Wheat.)

ROSANILINES—The aminated bases of fuchsine or magenta dyes.

The rosanilines are colourless, crystalline compounds, and only form dyes when united with an acid. Rosaniline ($C_{20}H_{21}N_3O$) and pararosaniline ($C_{19}H_{19}N_3O$) are obtained by precipitation of their salts with alkalies.

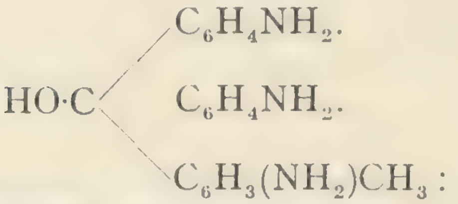
ROSANILINES (*Continued*)—

The actual dyes are the salts of these compounds, and include magenta, otherwise known as fuchsine ($C_{20}H_{20}N_3Cl$), rosaline nitrate, [$C_{20}H_{20}N_3(NO_3)$], rosaniline acetate, [$C_{20}H_{20}N_3(C_2H_3O)$], and parafuchsine ($C_{19}H_{18}N_3Cl$). These all dye wool and silk without a mordant, giving a magnificent fuchsine-red colour in solution, but are themselves in crystalline form of a bright metallic green lustre. They are soluble in hot water and alcohol.

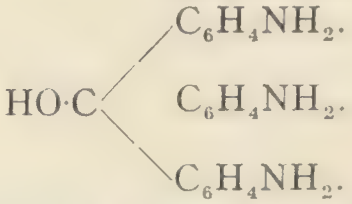
Rosaniline yields rosolic acid by treatment with nitrous acid.

The formulæ of rosaniline and para-rosaniline may be shown as below :

Rosaniline.



Para-rosaniline.



ROSCOELITE (Vanadium Mica)—Contains at times up to 28 per cent. V_2O_5.

ROSE OIL—See Attar of Roses.

ROSEINE (Fuchsine)—See Magenta and Rosanilines.

ROSELLE FIBRE (cultivated in the Federated Malay States) is of a jute nature, but alleged to be stronger than jute.

ROSEMARY (OIL OF)—The essential oil from the leaves of *Rosmarinus officinale* (N.O. Labiata), containing proportions of pinene, camphene (17 to 32 per cent.), cineol, borneol (14 per cent.), etc.; used in medicine, perfumery, and toilet preparations. One cwt. of the herb yields about 24 ozs. of the oil of sp. gr. 0·9 to 0·92 at 15° C., opt. rot. 0° to +15° at 20° C., and ref. ind. 1·466 to 1·470 at 25° C. The yield of fresh branches = 0·52 per cent. and the sun-dried material 1·2 to 2 per cent. The Sardinian, French, Dalmatian, Sicilian, and Spanish oils vary in their rotation and proportions of ingredients.

ROSIN—See Resins.

ROSIN OIL—The fraction from the destructive distillation of rosin (colophony) which comes over after the rosin spirit, and up to about 400° C., constituting the bulk of the total distillate. It exhibits a blue fluorescence, and is a complicated mixture of hydrocarbons of the hydrogenized retene type, phenols and free rosin acids ranging from 9 to 30 per cent. The last-named substances can be removed, together with some of the dark colour, by treatment with caustic soda. In general, it resembles mineral oil, and is of sp. gr. varying from 0·92 up to over 1·12. There are a number of grades, one of the refined quality being practically colourless (known as "pine oil"), while another of crude character is dark blue, and known as "blue rosin oil," or "blue billy." It is soluble in ether, turpentine, carbon disulphide, etc., and finds use as a lubricant and as an adulterant of boiled linseed and other oils. (See Rosin Spirit and Wood (Distillation).)

ROSIN SIZE (Resin Size)—Ordinary resin dissolved in alkali, used for sizing paper, etc. Some modern methods of its manufacture are described by C. N. Ridley (*Ind. Chem.*, 1930, vi., 369).

ROSIN SPIRIT (Pinoline) is a complex mixture of hydrocarbons and rosin acids, forming the distillate from the destructive distillation of rosin that comes over below 150° C., and amounting to from 2½ to 5 per cent. of the total distillate. It can be freed from associated acids by caustic soda, or refined by agitation with strong sulphuric acid and subsequent redistillation. When rectified, it has a sp. gr. of about 0·856 to 0·883, is miscible with petroleum spirit and turpentine, and is used as a solvent and substitute for turpentine in the paint and other trades. (See Rosin Oil and Wood (Distillation).)

ROSOLIC ACID ($C_{20}H_{16}O_3$)—A beautiful green-coloured crystalline substance with a metallic lustre and m.p. 270° C., chemically related to aurine and made by oxidation of phenol and cresol with arsenic and sulphuric acids. It is soluble in alcohol and ether, and is used in dyestuffs.

"ROSTKITT"—A rusting cement consisting of 85 parts iron filings, 10 flowers of sulphur, and 5 of sal-ammoniac stirred with water into a paste, its action resulting from the oxidation of the iron.

ROTA-METERS—Instruments for measuring the rate of flow of gases or liquids through a calibrated pipe, flowing upwards and lifting a float; used for the control of air in the bio-aeration method of sewage disposal, the control of chlorine for water purification, mixing gases in correct proportions, etc.

See W. H. Simmons and F. C. Sutton (*Ind. Chem.*, 1925, i., 473); an illustration (*Ind. Chem.*, 1931, vii., 53); and Recorders.

ROTATORY POWER—See Polarization (under Light, p. 536).

ROTTEN STONE—A mineral powder—disintegrated rock of limestone nature—found near Bakewell in Derbyshire and elsewhere, containing a large proportion of alumina; highly prized for polishing brass, etc.

ROUGE—A common name for an amorphous form of ferric oxide, employed as a pigment and for polishing glass, etc.; prepared by distilling ferrous sulphate. (See Iron (Ferric Oxide).)

RUBBER or CAOUTCHOUC—The prepared concreted juice (latex) of certain tropical trees collected by tapping, and imported from various parts of South and Central America, Africa, Madagascar, India, Borneo, Ceylon and neighbouring islands, Polynesia, etc.

Examined under powerful magnification, the latex particles are seen to range from 0·2 to 4μ in diameter, and to be in Brownian movement.

The Para rubber, which is the best in quality, is obtained from plants of the genus *Hevea* (N.O. Euphorbiaceæ), of which there are many species, the bulk being derived from the *Hevea brasiliensis*, although a number of varieties are obtained from other plants. In many cases the latex is mixed with that obtained from other species of Sapium, such as the *Tapura*, *Murupita*, and *Siring-gorana*, supplies

RUBBER (*Continued*)—

being obtained, for example, from the *Manihot glaziovii* (*Hevea* of the Euphorbia family), *Hancoria speciosa* (of lower value than *Hevea* and *Manihot*), and *Castilloa elastica*. In Africa, vines of the genus *Landolphia* yield the main supply; in Asia a number of different trees, including the *Ficus elastica*, are tapped; whilst *Hevea* is cultivated in Ceylon and the Malay States.

The *Ocotillo*, or candleweed of Arizona, is stated to yield a kind of rubber to the extent of about 200 lbs. gum to the ton.

The Sumatra trees yield on average from a "cattee" (1⅓ lbs.) to a kilogramme of dry rubber per annum, the tapping being the "V" cut on half the circumference, and later the spiral and herring-bone cut at about 60 cm. high.

From 70 to 80 per cent. of the world's supply of rubber is now produced within the British Empire. The real rubber in the raw material is always associated with resinous matter, some published analyses being as follows, calculated on the washed and dried products:

	Per Cent. Rubber.	Per Cent. Resins.
Para rubber, fine	91·9	1·9
Ceara	87·7	2·1
Columbian	81·9	6·8
Upper Congo	72·7	6·1
Madagascar	79·0	7·2
Borneo I.*a*	73·1	8·0

An analysis of dark red oil extracted from the kernels of rubber seed oil (*Hevea brasiliensis*) is given by Jamieson and Baughman (*Analyst*, 1931, **56**, 61). See also Y. Iwamoto (*Ibid.*).

The resinous constituents not improbably consist in large measure of the oxidation products of some constituents of the latex, including rubber, liquid unsaturated acids, a saturated solid fatty acid termed heveic acid, a phytosterol glucoside, etc. The resin content of *Hevea* rubber is about 2·8 per cent. (See "Oxidation of Caoutchouc," by J. M. Robertson and J. A. Mair (*J.S.C.I.*, 1927, **46**, 41 T), and paper on the resin content of rubber by Whitby, Dolid, and Yorston (*J.C.S.*, 1926, pp. 1448-1457).)

The function of these resinous bodies in the vulcanization of mixings containing accelerator and zinc oxide is the subject of articles by G. Martin and W. S. Davey (*J.S.C.I.*, 1925, **44**, 317 T) and W. S. Davey (*Ibid.*, 1930, **49**, 338 T).

According to K. Gorter, *Hevea* latex from trees thirty-five years old contains per litre 370 grms. caoutchouc, dry matter in serum 29·1 grms., including 5·3 grms. ash, 3·4 grms. protein, 14·5 grms. quebrachitol, 2·5 grms. sugar, and 3·4 grms. unascertained constituents (*J.C.S. Abs.*, cxxviii., I, 622). Undiluted *Hevea* latex containing below 17 per cent. rubber may show a sp. gr. exceeding 1·0, but generally the sp. gr. does not exceed that of water.

RUBBER (*Continued*)—

A. J. Altee found that the dry alcohol coagulum from the latex of *Ficus elastica* yielded 96·2 per cent. caoutchouc; that from *Castillio elastica,* 84·9 per cent.; *F. vogelli,* 72·9 per cent.; *F. glomerata,* 16·6 per cent.; *F. procera,* 12·1 per cent.; *F. fulva,* 1·1 per cent.; and *F. alba,* only a trace (*B.C.A.*, 1926, A, 1066).

Latex in process of spontaneous coagulation is stated to be swarming with bacteria, the principal of which is described as *B. pandora* of anaerobic character, capable of causing decomposition (A. S. Corbet, *B.C.A.*, 1929, B, 990); and the bacterial study of the natural coagulation of *Hevea* latex is the subject of an article by the same author (see *J.S.C.I.*, 1930, **49,** 36 T).

The rubber-juice, or latex, has a consistency of thick cow's milk or cream; it contains some 30 to 36 per cent. rubber, and exhibits a tendency to ferment and coagulate in the collecting cups, the latter property being generally attributed to the resin content, and to prevent this result a dilute solution of formaldehyde, ammonia, sodium carbonate, or sodium sulphite—preferably the latter—is now used.

Ammonia is effective when used in proportion of $\frac{3}{4}$ ounce of concentrated solution to each quart of latex, although it is advisable to use double this quantity; but for the majority of purposes $2\frac{1}{2}$ pints of saturated caustic soda solution to 100 parts latex, or a somewhat smaller proportion, is stated to do just as well. Hydrofluosilicic acid, or a suitable salt of it, as also formic acid, sodium fluoride, sodium silicofluoride, and certain cresolic preparations, known as "Agrisol" A and B, have also been reported as satisfactory coagulants and preservatives. Ammonia, however, is, according to some, the best preservative of latex.

The collecting cups for the latex are made of glass, glazed earthenware, or aluminium.

The subsequent coagulation can be effected by chemical, physical, and biological methods; but acetic acid in the proportion of 1 part to 1,000 parts latex is generally employed as the best coagulant when the latex contains 3 lbs. rubber per gallon, but to ensure a clear serum 1 part acid should be used to 660 parts latex. Formic acid is cheaper and is also used for this purpose, while alum is used in Sumatra.

The latex can be concentrated by evaporation under reduced pressure (preferably after addition of a little caustic soda or sodium carbonate), or alternatively by centrifugalization (up to 76 per cent. rubber content) and electrolysis.

A patented process of manufacture depends upon the electrolytic deposition of rubber from the latex upon an anode, which serves as a mould in any thickness from that of tissue paper to several inches. (See S. E. Sheppard (*B.C.A.*, 1927, B, 852); S. O. Cowper-Coles (*B.C.A.*, 1928, B, 615); some details of the process as described by P. Klein (one of the inventors) (*C.T.J.*, 1928, **83,** 511); and S. A. Brazier (*Ind. Chem.*, 1928, iv., 13).)

After coagulation the rubber is prepared in the forms of crêpe and sheet, the wet coagulum for the former being masticated and washed in mills, and then rolled out in ribbons, thus getting rid of the water-

RUBBER *(Continued)*—

soluble constituents, including the associated proteins; while to prepare it in sheet form it is made into slabs and rolled out smooth between wheels moving in opposing directions. The masticated rubber has a sp. gr. of about 0·914. The long strips of wet crêpe prepared as described are next dried in a darkened, well-ventilated chamber, during which period the whiteness disappears and the rubber takes on a pale yellow colour, constituting the "pale crêpe" of commerce.

Alternatively the dried rubber is subsequently "smoked" or "cured," so as to obviate mouldiness and tackiness, by hanging in a smoke-house, wherein it dries in the antiseptic smoke produced from wood fires on the ground beneath, and the dark reddish-brown translucent product is marketed as "smoked sheet." In place of "smoking" it has been found that soaking the sheet rubber in a dilute solution of *p*-nitrophenol is effective for the same purpose, without any detrimental effect.

Sodium bisulphite is extensively used for bleaching crêpe and sheet rubber.

Rubber latex is now used direct in paper-making, as beneficial results in the finish and waterproofing of the paper follow from its addition to the paper-pulp in the beating engine to the extent of from ½ to 1 per cent. The introduction of 2 per cent. into paper markedly increases its resistance to folding, but greatly improves the writing quality.

Its use in making boards and leather substitutes has been advocated, it having been proved that their strength can be considerably improved by its incorporation. It is also said to be of value in waterproofing wood, as it cannot be displaced by any expansion or contraction which the wood may undergo after being once deposited in its pores.

A solution of rubber in benzol admixed with a 2 per cent. solution of soap, when agitated violently, forms an emulsion in which the rubber constitutes the disperse phase in the form of globules of approximately the same size as it occurs in the natural latex, and in this form it may become a valuable commodity for many commercial applications.

Liquid latex contains some 60 per cent. water, and particulars have been published of a process (Calvert's) which consists of adding about 1 per cent. of some cheap reagent to the liquid latex, which causes a separation admitting of the removal of the water by filtration. It is stated that this prepared latex can be obtained in a dry form alone or in combination with such colloidal substances as casein, viscose, sulphur, alumina, or silica, and that the products dispense with the need of maceration in dough-making, also with the use of solvents for waterproofing, etc. It also admits of vulcanization by treating with precipitated sulphur or polysulphides, and can be used in this form for a number of industrial purposes. (See p. 775.)

An account of "The Direct Utilization of Latex," by P. Schidrowitz, is given in the *C.T.J.*, 1926, **79,** 587, and W. H. Stevens (*B.C.A.*, 1931, B, 73); the uses of concentrated latex by J. H. Carrington (*B.C.A.*, 1932, B, 236); and its concentration, together with an alkaline protective colloid by the so-called "Revertex process" (in which state

RUBBER (*Continued*)—

it contains only 20 to 30 per cent. water, and admits of vulcanization), is described by E. A. Hauser. (See *B.C.A.*, 1927, B, 148, and *C.T.J.*, 1927, **81,** 471.)

The spraying of latex with protective colloids such as glue is dealt with by W. C. Davey (*J.S.C.I.*, 1925, **44,** 515 T). Using glue, a powder can be obtained which keeps well and can be reconverted into a latex on addition of water. (See A. Van Rossem on "Rubber Latex" (*J.S.C.I.*, 1925, **44,** 33 T); pamphlet by H. P. Stevens (Rubber Growers' Association, Idol Lane, London), and *C.T.J.*, 1928, **83,** 383.)

The total consumption of rubber in 1928 was estimated at 680,000 tons.

In the pure state, caoutchouc is white, but, as known in commerce, it is brownish-black in colour, supple, elastic, tenacious, very combustible, a bad conductor of heat, a non-conductor of electricity (dielectric constant 2·35), and sp. gr. of from 0·92 to 0·96. Below 0° C. it becomes rigid and brittle; it softens when heated, and begins to melt at 120° C. The purification and fractionation of caoutchouc are subjects which have been investigated by Pummerer (with others). (See *B.C.A.*, 1928, B, 793.)

Chemically, caoutchouc has until recently been regarded as a hydrocarbon ($C_{10}H_{16}$) allied to gutta-percha and turpentine, and can be made synthetically from isoprene (C_5H_8), a volatile hydrocarbon liquid derived from turpentine; but a later investigation shows that it may have the constitution represented by $(C_5H_{10})_x$, obtainable by careful purification in crystalline form. (See *J.C.S. Abs.*, November, 1924, I., 1214). On the other hand, according to E. Lindmayer (*B.C.A.*, 1926, B, 924) unworked rubber has the formula $(C_5H_8)_{12}$ and masticated rubber $(C_5H_8)_6$, whilst vulcanization gives rise to $(C_5H_8)_6.S.(C_5H_8)_6$.

In chloroform solution at 0° C., caoutchouc is stated to be completely converted by the correct quantity of perbenzoic acid ($C_6H_5.CO.O.OH$) to the tough insoluble oxide $(C_5H_8O)_x$.

Purified plantation rubber can, it is stated, be completely hydrogenized in presence of platinum at 270° C. and about 100 atm. into a colourless amorphous mass of composition $(C_5H_{10})_n$ devoid of elasticity.

In sheet, tape, or thread form, rubber may be stretched very considerably without permanent loss of elongation; the spheres in its structure become distorted to ellipsoids, and recover their form after release from the strain.

According to J. R. Katz (*J.C.S. Abs.*, 1925, II., 667), unstretched *Hevea* rubber gives an amorphous X-ray spectrogram, whereas stretched rubber gives, in addition, a line spectrogram corresponding with an assemblage of crystals with their axes in the direction of the stretching, from which he concludes that caoutchouc consists of a crystalline and an amorphous substance. The stretching is accompanied by a development of heat and an increase in density rising from 0·9259 to 0·9487, which is lost again on resuming the original size. According to a recent report from the U.S. Bureau of Standards, highly purified rubber freed from the associated resins, proteins, etc., is a clear, colourless, trans-

RUBBER (*Continued*)—

parent, elastic solid which can be crystallized from an ethereal solution by cooling to about 80° C. below zero in transparent plates and distilled *in vacuo* at 100°.

Rendered plastic by heat or solvent, rubber in strips, tapes, or threads, and stretched to the most attenuated degree, can easily be moulded together with the hand or otherwise, with loss of elasticity and tension, and advantage is taken of this fact in the manufacture of so-called elastic thread and webs. After threads so made have been woven, the elasticity is restored by passing the fabric under a roller heated to about 63° C. Vulcanized threads, on the other hand, have to be forcibly stretched during weaving.

Rubber is soluble in turpentine, naphtha, benzene, carbon tetrachloride, and carbon disulphide, and many hydrocarbons and halogenated hydrocarbons are used as swelling agents. (See W. B. Lee, *J.S.C.I.*, 1930, **49,** 226 T.) It is extensively used in the manufacture of motor tyres, railway buffers, overshoes, macintosh garments, the cores of golf balls, as an anti-vibratory agent, lining large tanks, ball mills, chutes and filter-plates, and many other applications. Its uses in building works is the subject of an article by H. P. Stevens (Propaganda Department, Rubber Growers' Association, 2/4, Idol Lane, London, E.C.). Expanded by gas into highly cellular form, it has been found to constitute a very effective insulating medium for cold-storage purposes; also for rubber-proofing airship fabrics. "New Industrial Applications of Rubber" is the subject of an article by T. L. Garner (*Ind. Chem.*, 1930, vi., 227).

The "Joule effect" in relation to the structure of rubber is discussed by R. W. Lunn (see *J.S.C.I.*, 1925, **44,** 247 T); and an article dealing with the physical properties of rubber, by A. Van Rossem and H. Van der Meijden (*J.S.C.I.*, 1926, **45,** 67 T).

When rubber is immersed in a bath of melted sulphur at 125° to 140° C. it takes up as much as from 15 to 20 per cent., but much less is really in chemical combination in the vulcanized rubber, as the bulk of the sulphur can be dissolved out. For hard-rubber shaped articles the temperature is allowed to go as high as 160° C.

This vulcanization is believed to be dependent in the rubber upon certain accessory bodies in the nature of nitrogenous (protein) constituents, and it will be seen from what follows, that these have to be made good in the case of synthetic rubber by the introduction of certain nitrogenous organic bases.

The acidic character of the resinous constituents of crude rubber has some significance in regard to the vulcanization of rubber, as the acid content exercises a retaining influence. Neutralization gives rise to soaps, and these exercise an accelerating effect on vulcanization in the presence of catalysts. The amount of acid present in average samples of rubber would appear to be about 1·7 per cent. by weight. These facts have to be borne in mind when considering the effects of accelerating agents and the use of basic agents as referred to later in this article. For example, the effect of piperidine is largely due to the fact that it is

RUBBER (*Continued*)—

soluble in rubber, and is thus able to readily effect a complete conversion of the resin acids into soap.

According to B. Byson, the small amount of sulphur entering into chemical combination with the rubber is of no importance as a vulcanizing factor (see L. B. Sebrell (with others), *B.C.A.*, 1925, B, 1000, and article by N. Bacon, *Journ. Physical Chemistry*, 1928, **32,** 801), the character of vulcanized rubber depending rather upon physical changes involved in the process.

An investigation of G. Martin and F. L. Elliott showed that the percentage of sulphur combined with rubber at the standard curve adopted—viz., that which gives "a stress-strained curve which passed through 830 per cent. elongation under a load of 1·36 kg. per square mm."—is from 4·62 to 5·31.

Practical vulcanization, as ordinarily conducted, consists in the admixture (by kneading) of sulphur, with or without certain metallic sulphides (such as antimony sulphide), and various "filling" materials, such as zinc and lead oxides, and subjection of the resulting mixtures to a heat of 130° to 140° C. under some pressure. At a higher temperature, vulcanite or ebonite is produced, and this product, unlike ordinary rubber, is not soluble in turpentine and benzene.

In practice, the rubber is masticated and made plastic by steam-heated rollers, one of which revolves faster than the other, and after about half an hour the materials required to give hardness and colour and to ease the manipulation are added, the sulphur being incorporated last.

Rubber so vulcanized is less plastic than ordinary rubber, but it retains its character over a better range of temperatures, and is not nearly so susceptible to the action of various chemicals.

The ordinary "golden sulphide" (of antimony) used in this process gives to the finished articles their red colour, and is obtained by decomposing so-called Schlippe's salt with dilute sulphuric acid. (See Schlippe's Salt.)

This process of vulcanization is known as the "hot cure," but there are others, one—the "cold cure"—consisting of treating the rubber with the vapour or a weak solution of chloride of sulphur at ordinary temperatures, although this only results in a superficial vulcanization, and is not very widely used except for thin sheets or films.

Rubber can be vulcanized in the cold by hydrogen persulphide, but in the gaseous "Peachey" process the two gases which are employed are absorbed alternately by the rubber, and by chemical reaction between them sulphur is deposited throughout the material in a very finely divided nascent or atomic form, thereby securing thorough vulcanization. It consists in exposing the rubber to the action of sulphur dioxide and hydrogen sulphide gases alternately, and is said to yield a product quite comparable to that produced by the older sulphur process without the aid of heat. Pure dry hydrogen sulphide and pure dry sulphur dioxide, either in the liquid or gaseous states, do not interact, it is alleged, except in the presence of a third substance. (See E. Matthews, *B.C.A.*, 1926, A, 1108.)

RUBBER (*Continued*)—

Vulcanization can also be carried out in solution by dissolving rubber in benzol or naphtha containing hydrogen sulphide, and then mixing with a solution of sulphur dioxide in benzol, when viscosity increases, and, subsequently, the mixture jellifies, and after evaporation of the solvent, vulcanized rubber is left. It is the only process whereby rubber can be vulcanized in solution, affording at the same time the opportunity of incorporating with the rubber such substances as sawdust and leather, owing to the non-necessity of using high temperatures, and is thus capable of producing many mixtures suitable for wall and floor covering and other applications.

To speed up the combination or distribution of sulphur with rubber, many substances of limited value are variously employed, some inorganic ones such as zinc oxide, litharge, lime, and magnesia by reason of their insolubility, and others of organic character readily soluble in rubber.

Accelerators are used to save time in vulcanization, to improve the mechanical and ageing qualities of the products, and avoidance of "blooming" by using a minimum of sulphur. Vulcanizing can thus be effected at a lower temperature, and advantages are gained in the softening of the mixtures and lessening the variability of raw rubber.

Some act by parting with their sulphur constituent in nascent form, while others appear to produce a change which equals vulcanization in result without importing sulphur. (See note on the commoner mineral ingredients for rubber by D. F. Twiss and E. A. Murphy (*J.S.C.I.*, 1926, **45,** 121 T), and one on the effect of particle shape of mineral fillers by P. Schidrowitz (*C.T.J.*, 1926, **79,** 204).)

The long list of accelerators include mercapto-benzothiozole ("Captax"), diorthotolylguanidine, thio-carbanilide, aldehyde-ammonia, ethylaniline, hexa-methylene tetramine, piperidine, zinc-ethyl xanthate, quinoidine, para-nitroso-dimethylaniline, di- and tri-phenylguanidine, "superac," and various cinchona alkaloids. For the full exercise of accelerating power, the presence of zinc oxide appears to be necessary in many cases, including the use of zinc dialkyl-dithiocarbamates, but aldehyde-ammonia does not need the presence of other substances. The zinc alkylxanthates are among the most powerful of these agents, enabling, it is stated, rapid vulcanization to be effected as low as at 78° C. Some of the resulting products exhibit unusually high tensile strength.

"Valkacit" is the name of a commercial accelerator containing piperidine piperidyl-dithiocarbamate.

"Accelerene" is stated to be or to contain para-nitroso-dimethylaniline, which is credited with exceptional value.

Another series consists of colour bases, some of which, in addition to their accelerating power, impart permanent colour to the products.

"Piperidonium-piperidyl-dithiocarbamate" is described as an ultra-accelerator, one part in the presence of zinc oxide being alleged to increase the speed of vulcanization to from 300 to 400 times its usual rate.

When para-nitroso-dimethylaniline is used as the accelerator in

RUBBER (*Continued*)—

ordinary rubber-sulphur mixes, the vulcanized rubber does not attack copper, and when trinitrobenze is used as the vulcanizing agent the product is practically devoid of action on mercury and copper.

A comparison of the accelerating action of some reagents is given by Tanaka and Hara (*B.C.A.*, 1930, B, 521).

No satisfactory explanation has been yet forthcoming as to the precise action of these various accelerating agents, but possibly, as in the various ordinary processes of vulcanization, it is dependent upon the particular character—that is to say, atomic or molecular condition—in which the sulphur is set free to act its part in the process.

Various articles on these subjects are as follows: "A Comparative Study of Some Vulcanization Accelerators," by D. F. Twiss and F. S. Thomas (*J.S.C.I.*, 1923, **42,** 499 T); "Vulcanization Accelerators," by the same authors (*J.S.C.I.*, 1925, **44,** 100 T); "On the Heat Reactions occurring during Vulcanization of Rubber," by A. P. Perks (*J.S.C.I.*, 1926, **45,** 142 T); "On the Di- and Triaryl Guanidines," by W. J. S. Naunton (*J.S.C.I.*, 1925, **44,** 243 T); "On the Connection between the Chemical Constitution and Accelerator Action of the Diarylthioureas and Diarylguanidines," by W. J. S. Naunton (*J.S.C.I.*, 1926, **45,** 376 T); "The Nature of Vulcanization," by H. P. Stevens and W. H. Stevens (*J.S.C.I.*, 1929, **48,** 55 T; 1931, **50,** 397 T; and 1932, **51,** 44 T); note by W. H. Stevens (*Ibid.*, p. 60 T); articles by Blake and Boggs (*B.C.A.*, 1930, B, 829); and "Moulding and Vulcanization," by H. Willshaw (*Chem. and Ind.*, 1927, **46,** 760 and 783).

There is a process whereby rubber latex can be vulcanized by suitable agents under conditions which preclude coagulation, and in this form utilized to treat butter muslin, mosquito nets, chiffons, etc., thus giving them durability, strength, and elasticity; also applicable to cords and fabrics for motor tyres, a field of operation not practicable with ordinary rubber solution on a commercial scale.

"Onazote" is the name given to a spongy form of rubber made by absorption of a neutral gas under pressure which causes its expansion into bubbles during vulcanization, which can be carried to any desired degree. This cellular or honeycombed product is very useful as an insulating and packing material and is likely to find many industrial applications.

With respect to the colouring of rubber, the mineral pigments used impart properties to the product other than mere coloration. Under exposure to heat and sulphur, the coal-tar colours are too unstable to be used to any considerable degree, although some lake pigments and the insoluble azo and vat colours are used to some extent. "Colours Used in the Rubber Industry" is the subject of a paper (see *Chem. and Ind.*, 1931, **50,** 222) by Thompson and Bratby discussed at a recent meeting at Manchester, and a report of it and the discussion which followed is given (*C.T.J.*, 1931, **88,** 225).

Natural hydrocarbon gas black (see Carbon) serves as a reinforcing material, imparts high tensile strength to rubber, and can be introduced in considerable proportion, the product exhibiting a resistance to

RUBBER (*Continued*)—

abrasion and cutting. (See "Carbon Blacks and their use in Rubber," by N. Goodwin and C. R. Park (*Ind. Eng. Chem.*, 1928, **20**, 621-627).) Other reinforcing materials and pigments include finely divided china clays, lead sulphide, litharge, zinc oxide, whiting, barium sulphide and sulphate, calcium sulphate, silica, magnesium carbonate, antimony red compounds, arsenic sulphide, iron oxides, vermilion, zinc and lead chromates, ultramarine, etc.

For the mere softening of rubber many different substances are used apart from accelerators, such as naphthalene, paraffin oil, pine oil, tar, pitch, resin, gums, etc.

An incorporating mixture of 20 parts rubber with 80 parts of lead compounds has been placed on the market, and finds favour in some industrial applications.

The perishing of rubber goods proceeds much more quickly in the vulcanized articles than in those of pure rubber. It is said that plantation rubber—that is, rubber as it comes from the growers—may be stored for years without sensible loss of quality, and when vulcanized gives results comparable with freshly harvested material.

Exposed to the light, rubber changes gradually in two ways, the oxygen of the air and light taking active parts—first into a state of tackiness, and secondly into a brittle form, while in darkness there is little change. On the other hand, the vulcanized article begins to depreciate from the moment it is made; its life, however, is prolonged by storing in air saturated with moisture or petroleum vapour, being thus protected from oxidation and decomposition. The use of "Non-ox" is advocated for hot-air cures, in order to offset the oxidation which takes place simultaneously with the vulcanization (see Non-ox), and treatment with cold or hot liquid petroleum jelly has been recommended for restoring softness and pliability to rubber goods hardened by storage. (See K. Asano on "The Action of Light" (*B.C.A.*, 1925, B, 816), and "The Oxidation of Rubber," by M. Leon and W. H. Lister (*J.S.C.I.*, 1927, **46**, 220 T).)

An investigation concerning the permeability of rubber by gases has shown that it is one of dynamic equilibrium, in which the gas is dissolved at one side of the rubber at a rate proportional to its solubility and partial pressure, and diffuses through the rubber, from which it evaporates on the other side. Its relative permeability to certain gases has been given as follows:

Hydrogen = 1·00.

Nitrogen	0·16
Air	0·22
Argon	0·26
Oxygen	0·45
Helium	0·65
Carbon dioxide	2·90
Ammonia	8·00
Methyl chloride	18·50
Ethyl chloride	200·00

RUBBER (*Continued*)—

The production of so-called "methyl rubber" in Germany, which reached to the extent of 165 tons per month during the Great War, was made by polymerization of the hydrocarbon butadiene (C_4H_6 or $CH_2:CH.CH.CH_2$) or dimethylbutadiene (C_6H_{10} or $CH_2:CMe.CMe.CH_2$) (primarily prepared from acetone) by placing it in hermetically sealed barrels and allowing it to remain undisturbed for about six months at a temperature of 32° C., the rubber being thus obtained as a spongy white mass which has to be bored out of the containers. According to one account, a mixture of acetylene and ethylene condenses, when suitably heated, to butadiene, and by methylation this is converted into isoprene ($CH_2:C(CH_3).CH:CH_2$) (or C_5H_8), which again is polymerized by concentrated hydrochloric acid into synthetic rubber. It lacks elasticity when used for making soft rubber goods, and "elasticators," or oily materials, have to be incorporated for such applications; it is more useful in making so-called "vulcanites." These elasticators are basic substances of a nitrogenous nature, such as aldehyde-ammonia, which will combine with the synthetic rubber, the resulting compound proving more amenable to vulcanization. This synthetic rubber as at present made is deficient in the physical (pivotal) properties of the natural article. (See L. E. Weber on synthetic rubber (*C.T.J.*, 1926, **78**, 470; *Ibid.*, 1927, **81**, 543) and Isoprene.)

It is reported from New York that a new synthetic rubber named Duprene has been developed by Messrs. E. I. Du Pont de Nemours and Co., requiring only acetylene, salt, and water as raw materials. (See *C.T.J.*, 1931, **89**, 528.) The process consists in the "catalytic polymerization of acetylene to monovinylacetylene," which is then treated with hydrogen chloride to produce chloroprene, and the rubber is then produced by the "controlled polymerization of chloroprene." It is claimed that the new synthetic rubber has greater resistance to the action of petrol and paraffins than natural rubber and can be vulcanized by the application of heat alone, but more research will be required before the new product becomes profitable commercially. (*The Times*, November 4, 1931.)

Other References: "Preparation of Rubber before Vulcanization and its Manufacture" (*Ind. Chem.*, 1925, i., 127); "Swelling of Vulcanized Rubber in Liquids," by J. R. Scott (*B.C.A.*, 1931, B, 34); "Structure of Rubber; Swelling Experiments in Various Liquids," by P. Bary (*B.C.A.*, 1930, B, 727); "Compressibility of Rubber," by Adams and Gibson (*B.C.A.*, 1930, B, 781); reviews of "The Rubber Industry, 1926-1931," by S. A. Brazier (*Ind. Chem.*, 1927, iii., 13; 1928, iv., 13; 1929, v., 8; 1930, vi., 30; 1931, vii., 9; and 1932, viii., 27); "Influence of Rubber 'Resins' in Zinc Oxide-accelerator Mixings," by W. S. Davey (*J.S.C.I.*, 1930, **49**, 338 T and 343 T); "Rubber in Chemical Industry" (*C.T.J.*, 1927, **80**, 365); "Rubber Equipment for the Chemical Industry" (*Ind. Chem.*, 1929, v., 229); "Rubber Service Laboratory" (*C.T.J.*, 1931, **88**, 100); "Physical Tests of Rubber" (*C.T.J.*, 1925, **77**, 359); "Vapour-pressure Diminution of Rubber

RUBBER (*Continued*)—

Jellies," by P. Stamberger (*J.C.S.*, 1929, p. 2319); "Chemical Risks in the Rubber Industry," by R. Brightman (*Ind. Chem.*, 1930, vi., 252); "New Industrial Applications of Rubber," by T. L. Garner (*Ibid.*, 1930, vi., 227); "Ultra-Violet Light Testing in the Rubber Industry," by T. L. Garner (*Ind. Chem.*, 1931, vii., 395); "Rubber Cements and Adhesives," by S. D. Sutton (*Ind. Chem.*, 1932, vii., 65); books on rubber by B. D. Luff (Ernest Benn, Ltd.); L. E. Weber (C. Griffin and Co.); *A Digest of Knowledge concerning Synthetic Rubber*, by S. P. Schotz (Ernest Benn, Ltd.); *Latex: its Occurrence, Collection, Properties, and Technical Applications*, by E. A. Hauser (Chem. Catalog. Co., Inc., N.Y.).

Reclamation of Rubber—Various processes have been devised for the reclamation of rubber from vulcanized waste. By the chief process the cut sheet-waste is heated with alkali solution of from 5 to 6 per cent. strength for twelve to eighteen hours at 365° to 387° F. under pressure (which removes sulphur), and after steaming or heating with hot water at about 350° F. is washed and then worked up with oil in a masticator, and utilized for admixture with rubber to be used for revulcanization or otherwise. (See *Ind. Chem.*, 1927, iii., 265; J. B. C. Kershaw (*Ind. Chem.*, 1928, iv., 115); C. S. Powell (*Ind Eng. Chem.*, 1931, **23,** 701); and R. F. Pearson (*B.C.A.*, 1931, B, 76).)

Vulcanite (**Ebonite**) is made by heating 2 parts of indiarubber with 1 part of sulphur to a temperature of about 150° C., and although it is liable to twist under the influence of boiling weak acids, it is largely used for lining tanks, for making pumps, pipes, taps, buckets, tubing, and unions for use in chemical works, as also for combs and other articles. At above 140° C., if used for lining chemical plant, etc., it requires to be suitably reinforced with metal work. Gutta-percha is vulcanized in the same way. Ebonites may contain from 15 to 50 per cent., but usually about 30 per cent. sulphur, and it has been suggested that a body of the constitution $C_{10}H_{16}S_2$ is the essential constituent of hard vulcanite. (See D. F. Twiss (*J.S.C.I.*, 1925, **44,** 106 T).) Writing of its insulating character, W. H. Nuttall states that the maximum dielectric constant is obtained with a percentage of sulphur corresponding to the formula $(C_5H_8)_4S$—that is, 10·5 per cent. sulphur (*Chem. and Ind.*, 1928, **47,** 1366).

For use in connection with electrical units and the manufacture of moulding plastics there is now a great demand for ebony dust, and the preparation of this material is described in an article (*Ind. Chem.*, 1929, v., 192). In a prepared porous form ebonite is used as a filtration material (see *C.T.J.*, 1931, **88,** 592). The deterioration of ebony when exposed to light and air is attributed by Fry and Porritt to the decomposition of some caoutchouc-sulphur compound accompanied by evolution of hydrogen sulphide (*B.C.A.*, 1929, B, 828). Webster and Porritt attribute the traces of sulphurous and sulphuric acids developed in the surface films of ebonite containing no free sulphur, to the oxidation of the evolved hydrogen sulphide (*B.C.A.*, 1930, B, 293).

RUBBER (*Continued*)—

Many enamels are used for polishing vulcanized rubber articles, such as "chloride-cured starch," casein, condensed milk, and spirit varnishes. Another one advocated, is made by boiling equal weights of bleached white shellac and borax in distilled water, with or without a little gum arabic, the prepared mixture being applied by brushing on or dipping the articles.

The methods of colouring hard rubbers and ebonite is the subject of a paper by W. J. S. Naunton (published in the February issue of the *Journal of the Society of Dyers and Colourists*, 1929, part of which is reproduced in the *C.T.J.*, 1929, **84,** 242).

RUBBER-SEED OIL, as extracted from the seeds of the Para rubber-tree, may possibly prove a substitute for linseed oil, but it has been shown that the seed depreciates on storage, and yields an oil containing up to 25 per cent. of free fatty acids, which is not generally suitable for that purpose. It exhibits a slower drying character than linseed oil, and it is necessary to prepare a "boiled" oil for commercial purposes which is free from fatty acids. It is stated to find a ready sale in the U.S.A. for soap manufacture. The sun-dried kernels yield about 47 per cent. oil of sp. gr. 0·925 to 0·93 at 15° C., sap. v. 188·5 to 192·5 and i.v. of 128·3 to 143·3. The residual cake is said to be a good cattle food. (See *C.T.J.*, 1930, **87,** 301, and *Analyst*, 1931, **56,** pp. 61 and 62.)

RUBBER TYRES—An article descriptive of their manufacture will be found in the *Ind. Chem.*, 1925, i., 237.

RUBIAN—A name sometimes given to the glucoside principle contained in madder (the root of *Rubia tinctoria*), which yields alizarin and glucose by hydrolysis. (See Alizarin.)

RUBIDIUM (Rb)—Atomic weight 85·4, and two alleged isotopes of masses 85 and 87; sp. gr., 1·52. A somewhat rare element met in association with potassium and sodium in the minerals *lepidolite, porphyrites,* and *carnallite*. It is a soft, silvery-white metal, m.p. 38° to 38·5° C., and, when sublimed, forms small needle-shaped crystals. It can be prepared by the electrolysis of the fused chloride, or heating the carbonate with carbon. The mother liquor from the extraction of potassium chloride from carnallite contains the salts represented by $RbCl,MgCl_2,6H_2O$ and $CsCl,MgCl_2,6H_2O$, and constitutes a good source. It is capable of decomposing water, and takes fire in the air, yielding the oxide, so that, like sodium, it has to be kept under naphtha. It gives off a green vapour when heated, and its salts, which are soluble, resemble those of potassium in their general characters, and give a dark red colour to flame. (See Jander and Busch on "Extraction of Rubidium and Cæsium from Carnallite," *B.C.A.*, 1931, A, 49.)

RUBIES—Gems of pure clear red corundum (aluminium oxide) of great hardness. Inferior spinels are also sold as rubies. (See Aluminium.)

RUE (OIL OF) is obtained (0·18 per cent.) by distillation of the herb known as garden rue (*Ruta graveolens*, N.O. Rutaceæ) with water, and contains a ketone with other bodies in admixture. Species are found in the South of Europe, Canary Islands, and temperate parts of Asia. It is viscid, of strong, unpleasant odour and bitter taste, and is used medicinally as an antispasmodic, etc. Sp. gr., 0·83 to 0·845 at 15° C.; opt. rot., +0° to +2·30° at 20° C.; and ref. ind., 1·432 to 1·436 at 20° C. (See Rutin.)

"RUHMKORFF" INDUCTION COIL—See Induction Coils and Oxygen (Ozone).

RUM—An alcoholic drink of characteristic odour distilled from fermented molasses in the West Indies, and ordinarily containing about 48 per cent. alcohol associated with a large amount of ethyl acetate. It is frequently coloured with caramel, and is credited as having a greater food value than any other spirit.

RUSA GRASS—See Ginger-Grass Oil.

RUST—The corrosion known as rust on iron articles is very variable in composition, and results from the chemical action of carbon dioxide and moist air, associated with, or resulting from, electrolytic action. It always contains some ferrous oxide, the proportion decreasing with age, and its formation is probably the first stage in the production of rust. (See U. R. Evans (*J.S.C.I.*, 1928, **47,** 316 T; *C.T.J.*, 1929, **85,** 420), and R. Stumper (*J.C.S. Abs.*, 1925, II., 702).)

Cast iron of high impurity corrodes slowly, whereas the purest wrought iron rusts very rapidly.

Iron is said to be perfectly protected against rust by coating with certain oils such as castor oil and wool-grease oil which have been treated with phosphoric anhydride in the cold or at a moderate temperature, and containing the phosphoric acid in combination. In this way greases are produced, which may be used in dilute solutions, using solvents, such as benzol or alcohol, or admixed with other greases, oils, varnishes, and paints. A. V. Blom (of Berne) has described a lead pigment made from reduced lead, forming a so-called "pyrosol of lead in litharge," which is afterwards mixed with linseed oil and then painted or sprayed on the iron to be protected. The mixture is said to penetrate the surface of the iron by diffusion, thus contributing to the protection, which is stated to be excellent.

A process for the electrolytic removal of rust from iron and steel articles has been devised, using a bath containing ¾ lb. commercial caustic soda, a similar quantity of washing soda, ¼ lb. of salt cake, and 1 ounce of sodium cyanide in a gallon of water, the article to be de-rusted forming the cathode, at a temperature approximating boiling-point.

RUSTLESS (STAINLESS) IRON AND STEEL—A chromium-iron alloy, containing from 12 to 16 per cent. chromium, and (for most purposes) not more than 0·35 per cent. of carbon, now largely used for the manufacture of cutlery, turbine blades, acid pumps, hydraulic pumping rams and rods, and exhaust valves for aircraft engines. In some cases

RUSTLESS IRON AND STEEL (*Continued*)—

a proportion of the chromium can be replaced to advantage by copper, nickel, silicon, etc. It is not attacked by any kind of water, or alkaline salts, ammonia, vinegar, fruit juices, or atmospheric agency, but ammonium chloride has some action upon it. It is also attacked by 20 per cent. acetic acid after some time, and more quickly when hot, but it is not dissolved by strong nitric acid, while sulphuric and hydrochloric acids attack it readily.

Nickel, when used in quantities of from 25 to 30 per cent., has a great effect in increasing the resistance of steel to corroding influences, and is practically used in the proportion of about 8 per cent. with 18 per cent. chromium in making some varieties. (See *C.T.J.*, 1925, **76,** 516.)

It is important to note that "rustless" or "stainless" steel is made in many varieties adapted to particular applications, and possessed of varying properties accordingly.

Before rustless steel can exhibit resistance to the highest extent it must be in a correctly heat-treated condition—that is to say, it must be heated to about 940° C. and then quenched in oil. This, however, makes it too hard for some purposes, and to reduce this, it is reheated to 650° C., which treatment also improves the ductility.

The pickling bath treatment, giving the best results with mild stainless steel, is reported to consist of ten minutes' immersion in a 50 per cent. commercial hydrochloric acid, then transference without washing to 20 per cent. nitric acid for twenty-five minutes, both in the cold, the proper pickling being an important factor in its manufacture.

It is reported that articles of any metal may be rendered unstainable by the electrolytic deposition of a film of chromium. In the home and for many purposes, including construction of buildings, these various makes of so-called austenitic steels find constantly increasing employment. The possibilities of stainless steel are dealt with in articles by W. H. Hatfield (*Ind. Chem.*, 1925, i., 64; 1926, ii., 11). See also *Chem. and Ind.*, 1926, **45,** 568, and *Ibid.*, 1929, **48,** 1060.

An old process for preserving iron against rusting consists of preparing a film of magnetic oxide of iron by the application of heat in a suitable gaseous atmosphere such as steam or carbon dioxide.

Another patented way of coating iron with magnetic oxide consists in coating the article by electro-deposition with a metal or alloy which volatilizes at about 1,000° C., and then heating to that temperature in a furnace, causing the volatilization of the coating, and forming at the same time a layer of triferric tetra-oxide on the surface.

It has been pointed out that the terms "stainless" and "non-corrosive" are inaccurate as applied to the new chrome steels, which are more accurately described as "corrosion-resistant." (See J. A. Matthews (*Ind. Eng. Chem.,* December, 1929), who gives in his article a table of analyses of various types of steels now on the market, including stainless steel, stainless irons, and several makes of "Rezistal"; *Stainless Iron and Steel,* by J. H. G. Monypenny (Chapman and Hall); Iron, and the bibliographical references given under that heading (pp. 498 and 499).)

RUSTLESS IRON AND STEEL (*Continued*)—

The "Coslettising," "Parkerising," and "Bondering" processes of rust-proofing are described in the *C.T.J.*, 1931, **89**, 332. See also O. W. Roskill on the "Parker" process (*Ind. Chem.*, 1932, viii., 59), and reference to the "Wild" chromium process (*C.T.J.*, 1932, **90**, 217); Adeps Lanæ, Corrosion, Metals (pp. 576 and 577), Paints, Passivity, and Rustless Iron.

RUTHENIUM (Ru) **and its Compounds**—Atomic weight, 101·6; atomic number, 44; sp. gr., 12·26. A hard, brittle, greyish-black metal of the platinum group, with the ores of which it is found in association, also in the very rare mineral *laurite* as sulphide (RuS_2). It is practically insoluble in acids other than aqua regia, has a higher m.p. than platinum —between 1,950° and 2,000° C.—forms, it is stated, a trichloride which decomposes into its elemental constituents at 845°, a tetra-chloride ($RuCl_45H_2O$) which is crystalline, deliquescent, and very soluble in water; also other salts corresponding to the sesquioxide, which is one of the four oxides known—namely, RuO, Ru_2O_3, RuO_2, and a very volatile RuO_4. It is also said to form a potassium combination ($KRuO_4$) analogous to potassic permanganate ($KMnO_4$), and two carbonyls, the dicarbonyl being soluble in water.

RUTILE—Mineral titanium dioxide (TiO_2), of crystal system, No. 2, and sp. gr. 4·18 to 4·22, occurring in several of the U.S.A. and elsewhere. (See Titanium.)

RUTIN (**Sophorin**) ($C_{33}H_{42}O_{20}4H_2O$)—A substance originally discovered in rue (*Ruta graveolens*) and occurring in a number of plants, including *Viola tricolor*. It is a glucoside of pale yellow, crystalline character, sparingly soluble in water and alcohol, which upon hydrolysis yields rhamnose. The petals of *Eschscholtzia californica* are said to contain 5 per cent. of rutin. (See J. Rabaté (*B.C.A.*, 1930, A, 1484) and Rue.)

RYE—A genus of grasses or cereal (secale, cereale) used in making Hollands and a variety of Russian beer ("Kvass") and from which the black bread of Germany is also made. The straw is valued for straw-plait, being tougher than that of other corn plants. (See Ergot of Rye.)

Rye oil, constituting about 2 per cent. of the rye, has been examined by J. W. Croxford (*Analyst*, 1930, **55**, 735), who found the sp. gr. as varying from 0·9374 to 0·9412; i.v., 118·3 to 129·9; and sap. v., 178·7 to 173·4 in respect of two samples. The calculated composition of the fatty acids contained in one of the oils examined was linolic, 62·65 per cent.; oleic, 10·35 per cent.; solid, 27·0 per cent.; the unsaponifiable content being abnormally high. It is classified as a semi-drying oil.

RYE-GRASS (**Lolium**)—Used as forage, the perennial type being most cultivated.

SABADILLA (**Cevadilla**)—The dried ripe seeds of *Schœnocaulon officinale*, a Mexican plant of the N.O. Melanthaceæ from which veratrine is prepared. (See Veratrine.)

SABINENE—A terpene ($C_{10}H_{16}$) contained in savin, juniper, and marjoram oils, of b.p. 163° to 165°; it forms a hydrochloride and a nitrosochloride. (See Savin Oil.)

SACCHARATE (Strontium)—There are two compounds of sucrose with strontia, known respectively as mono-strontia-monosucrose ($C_{12}H_{22}O_{11}$, SrO) and the di-strontia compound ($C_{12}H_{22}O_{11}$,2SrO). (See Mackenzie and Quin (*J.C.S.*, 1929, p. 959) and Sugar.)

SACCHARIC ACID ($C_6H_{10}O_8$)—A soluble, deliquescent product of the oxidation of cane sugar, glucose, starch, etc., by nitric acid.

SACCHARIDES—See Carbohydrates and Sugar.

SACCHARIFICATION—Conversion of starch, wood, etc., into sugar. (See Alcohol, Beer, Glucose, Sugar, and Wood.)

SACCHARIMETER—An instrument for ascertaining the amount of sugar in a solution by determining the specific rotatory power—that is, measuring the angle through which the plane of polarized light is turned when passing through its solution in comparison with that of a solution of known strength. The term is also applied to an apparatus for measuring the volume of carbon dioxide evolved by fermentation of a definite quantity of sugar. (See Polarization, p. 536.)

SACCHARIN ("SAXIN") (Imide of Ortho-sulphamino-benzoic Acid) ($C_7H_5NSO_3$ or $C_6H_4CO.SO_2.NH$)—A synthetically prepared ammonia derivative, white, crystalline, and having (in common with its hydrated sodium salt) a sweetening power from 300 to 560 times that of cane sugar; prepared from toluene by use of chloro-sulphonic acid, and used as a sweetening substitute for sugar, particularly in diabetic cases. Its sweetness is greatly affected by slight chemical changes in the molecule. The generally accepted strengths of saccharin and dulcin are 1 : 450 and 1 : 250 respectively. (See *Ind. Chem.*, 1925, i., 5, and 1927, iii., 161; and *C.T.J.*, 1925, **77**, 477.)

SACCHAROMETER—Hydrometer graduated to test the strength of sugar solutions by ascertaining their density, and reference to tables prepared from known strengths.

SACCHAROSES (Saccharides)—See Carbohydrates and Sugar.

SAFETY GLASS—See Glass.

SAFETY (INDUSTRIAL)—See W. H. Ibbotson (*Ind. Chem.*, 1928, iv., 243); R. Brightman (*Ibid.*, 1930, vi., 154, 209, and 252); Annual "Reports of the Safety in Mines Research Board" (H.M. Stationery Office); a descriptive account of the Home Office Museum (*Ind. Chem.*, 1931, vii., 25); D. Pratt on "Cleaning and Repair of Plant" (*Ind. Chem.*, 1931, vii., 246); G. B. Jones on "Cleaning and Inspection of Dyestuffs Vessels" (*Ibid.*, 269); and other papers (*Ibid.*, 337-340); *C.T.J.*, 1931, **88**, 467; *Ibid.*, p. 557; *Chem. and Ind.*, 1931, **50**, 489; J. D. Pratt (*Chem. and Ind.*, 1932, **51**, 228); Lead (p. 526), Poisons, and Antidotes.

SAFETY LAMPS—Used by coal-miners, and constructed on the known fact that a flame has difficulty in crossing or passing through wire gauze due to the conductivity of the metallic gauze which carries away the heat of the burning flame inside the lamp to such an extent that the explosive gas outside the lamp is kept below the temperature necessary for its ignition. (See "Publications of the Safety in Mines Research Board" (H.M. Stationery Office) and Carbon Monoxide, p. 145.)

SAFFLOWER (**Carthamus,** N.O. Compositæ), derived from the florets of the herbaceous *Carthamus tinctorius* of the Levant and Orient, and largely cultivated in India, is a natural red colour used as a dyestuff for cotton goods without a mordant, and for other colouring purposes. The plant is of greater value in respect of the oil contained in the seeds 14 to 30 per cent.), yielding, on average, about 20·5 per cent.; sp. gr. at 15·5° C. 0·9258, i.v. 130 to 150, sap. v. 197·31, and ref. ind. 1·477 at 16° C. The oil is said to contain up to about 0·5 per cent. linolenic and isolinolenic acids, 39 to 50 per cent. linoleic acid, 34 to 37 per cent. oleic acid, 5 to 6 per cent. palmitic acid, 3 to 4 per cent. stearic acid, glyceryl residue (C_3H_2) 4·6 per cent., and unsaponifiable matter 0·5 to 1 per cent. (J. Zukervanik, *B.C.A.*, 1929, B, 402). The characteristics of American safflower oil are given by Jamieson and Gertler (see *Analyst*, 1929, **54,** 347), and the constitution of carthamin, the red colouring matter of safflower, is subject of a paper by C. Kuroda (*J.C.S.*, 1930, p. 752).

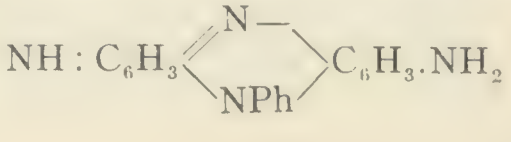
The oil has drying properties, and can be used in varnish-making, and for making soft soap. The cake is stated to be valueless as feeding stuff on account of its high content of fibre.

Dried to a gelatinous mass, safflower oil is used as "Roghan" or "Afridi wax," in preparing wax cloth. The "sweet oil" of Bombay is a mixture of oils expressed from safflower, earth nuts, and *til* seeds.

SAFFRON (**Crocus**)—A yellow colouring matter, being the dried stigmas of the saffron crocus (*Crocus sativus*), cultivated in Spain, France, Austria, and Italy; used as a dye, a flavouring in cookery, and in medicine. Valencia and Alicante saffrons are said to be the best.

Saffron appears to contain a crystalline glucosidal body, constituting the bitter principle, named picrocrocin, a yellow colouring matter named crocin, and a nitrogen content of 2·3 to 2·4 per cent. The Austrian variety ("cut saffron") is known as *Crocus electus*. (See H. E. W. Lutz on "Picrocrocin" (*B.C.A.*, 1930, A, 1590).)

SAFRANINES—A group of 2 : 8 diamino derivatives, being crystalline aniline dyes of metallic green lustre (including mauve) related to toluylene red, made by oxidation of aniline and para-toluylenediamine, etc. They are soluble in water, and dye red and violet. Pheno-safranine is the simplest member of the group, and has the formula :



$$\mathrm{NH:C_6H_3}\begin{matrix}\mathrm{N}-\\ \mathrm{NPh}\end{matrix}\mathrm{C_6H_3.NH_2}$$

SAFROLE [$C_{10}H_{10}O_2$ or $C_6H_3C_3H_5(OOCH_2)$]—The essential constituent of sassafras oil from the bark of *Sassafras officinalis* of N. America; contained also in losoh oil (from the wood of *Cinnamomum parthenoxylon* of the Malay States), camphor wood, and other plants. It is clear, colourless, of sp. gr. 1·1, m.p. 11° C., and b.p. 233° C.; soluble in alcohol and ether, of aromatic odour, and upon cooling to −20° C. crystallizes in rhombic prisms; used in perfumery and, by oxidation with chromic acid, yields heliotropin. (See Perkin and Trikojus on "Synthesis of Safrole" (*J.C.S.*, 1927, p. 1663), and Sassafras Oil.)

SAGE (OIL OF)—An essential oil distilled (about 1·5 per cent.) from the fresh leaves of *Salvia officinalis,* a genus of Labiatæ, growing in north Mediterranean countries, containing sesquiterpenes, cineol, borneol, etc. Sp. gr., 0·910 to 0·930; opt. rot., +10° to +25° at 20° C.; ref. ind., 1·462 to 1·467 at 20° C.; used in perfumery and making condiments. Details of its constituents are given by L. F. Morani (*B.C.A.*, 1929, B, 622).

SAGGARS—Cases of baked fire-clay in which certain classes of pottery and porcelain are fired to protect them from the direct heat.

SAGO—Consists almost entirely of starch, and is prepared in the islands of the Indian Archipelago from the pith of the stems of certain palms, including the *Sagus* (*Metroxylon*) *rumphii* W., *S. raffia* Jacq., *S. lævis,* etc., which grow freely in Java, the Moluccas, Borneo, Siam, New Guinea, Sumatra, and elsewhere. Each tree is stated to yield about 600 lbs. pith. (See Cassava and Tapioca.)

SAJJI—A native Indian soap substitute, being an alkaline substance found as a deposit on certain waste lands. (See Ritha.)

SAKI (**Saké**)—A beer made by the Japanese from rice by a process of fermentation induced by a mycelium named *koji,* which grows on steamed rice. This and various species of aspergillus are known to produce, under suitable conditions, kojic acid ($C_6H_6O_4$) from rice, sugar, glycerol, etc., and this acid, which is closely related to glucose, has been recently synthesized. (See Challenger, Klein, and Walker, *J.C.S.*, 1931, p. 16.)

SAKOA OIL, from Madagascar, is obtained from the fruit of *Sclerocarpa caffra.* The seeds contain 56 per cent. of a non-drying oil, having a sp. gr. at 15° C. of 0·9167, sap. v. 193·5, and i.v. 76·6.

SAL-AMMONIAC—An old name for ammonium chloride marketed as "sublimed lump," first and second qualities.

"SALERNI" PROCESS—A new low-temperature carbonization. (See R. V. Wheeler, *Gas Journ.*, 1931, **196,** 783.)

SALICIN ($C_{13}H_{18}O_7$)—A glucoside found (from 1 up to 7 per cent.) in varieties of *salix* and *populux* (willows and poplars), also in the flowerbuds of meadowsweet and the green part of certain herbaceous *spireas.* In the pure state, it is a crystalline odourless substance, soluble in water, and possesses febrifugal properties. In the human body it undergoes decomposition, giving rise to the production of salicylic acid, and is used as a specific in the treatment of acute rheumatism. (See Saligenin.)

SALICYL ALDEHYDE (o-Hydroxy-benzaldehyde) ($OH.C_6H_4.CHO$)—A yellow oily substance of sp. gr. about 1·165, soluble in alcohol and ether, and prepared by interaction of phenol and chloroform in presence of potassium; used in perfumery.

SALICYLIC ACID or ORTHO-HYDROXY-BENZOIC ACID ($C_7H_6O_3$ or $C_6H_4(OH)COOH$) occurs naturally in the blossom of *Spiræa ulmaria* and in combination in oil of wintergreen. It is a white, crystalline body (m.p. 157° to 159° C.), prepared by the action of carbon dioxide at 130° C. upon sodium phenoxide (phenate) ($C_6H_5.ONa$) in a closed vessel, the sodium phenyl carbonate thus produced being subsequently transformed into mono-sodic salicylate, and from it the acid is obtained by the action of sulphuric or hydrochloric acid. It can also be easily obtained by chemical methods from salicin, coumarin, phenol, oil of wintergreen, and indigotin. It is little soluble in cold water, but readily soluble in alcohol, ether, and hot water; is a good antiseptic, and is much used in the dyestuffs industry and the manufacture of aspirin; also medicinally and as a preservative agent by glue-makers and for foods and skins. When heated with powdered glass or quicklime it breaks up into phenol and carbon dioxide.

SALIGENIN ($C_7H_8O_2$ or $OH.C_6H_4.CH_2OH$) (**o-Hydroxy-benzyl Alcohol**) (m.p. 85° to 86° C.)—A crystalline product of hydrolysis, accompanying dextrose, as produced from the glucoside named salicin ($C_{13}H_{18}O_7$).

SALINOMETERS—For ascertaining saline density of water in ships' boilers.

SALIVA—An alkaline mixture of fluids secreted by various salivary glands (the ducts of which discharge into the mouth) containing an active principle termed ptyalin which behaves as an enzyme and converts starchy matters into sugar (maltose and dextrin). It contains about 1½ parts ptyalin per 1,000, and is most active at 40° C.

SALMON OIL—See Fish Oils.

"SALODINE"—An iodized salt advocated as a preventive of goitre.

SALOL or PHENYL SALICYLATE ($C_{13}H_{10}O_3$ or $C_6H_4.OH.CO_2.C_6H_5$)—A white, crystalline substance, m.p. 42° C., and b.p. 172° C.; possessing antiseptic properties and used medicinally for internal applications; soluble in alcohol, ether, etc.

SALSOLA—A genus of seashore plants, rich in salts, which, when burned, yield an ash containing sodium carbonate. (See Barilla and Kelp.)

SALT (common)—See Sodium Compounds.

SALT CAKE—See Sodium Compounds.

SALT OF LEMON—See Salt of Sorrel.

SALT OF SORREL (Salt of Lemon)—See Potassium (Binoxalate, p. 729).

SALTPETRE (Nitre)—See Potassium Compounds, p. 728.

SALTS—See Acids and Chemical Compounds, p. 170.

"SALUNOL" is described as a concentrated aqueous solution of sodium hypochlorite, and advocated for use as a sterilizing and disinfecting agent in food industries, and particularly (when frozen in ice) for the preservation of trawled fish on board ship, etc. (See Sodium (Hypochlorite) and Eau de Javelle.)

"SALVARSAN" (**"606"**) (**"Kharsivan"**) is a very complex organic compound (di-hydroxy-diamino-arseno-benzene dihydrochloride), containing arsenic in combination, and is used in the treatment of syphilitic cases; it is not, however, a chemically pure substance.

"Salvarsan" can be combined with glucose, forming a compound (probably of glucoside nature), which is soluble in water, more stable than ordinary "salvarsan," and compares favourably with it in respect of therapeutic property.

Other preparations used for the same purpose are the arseno-benzol compounds known as "914," sulfarsenol, silver salvarsan (a mixture of colloidal silver and sodium salvarsan), and "eparseno" (an amino-arseno-phenol containing 40 per cent. arsenic), the latter being used for subcutaneous injection. (See Arsenobenzol and "Stabilarsan.")

SALVIA—See Sage Oil.

SAL-VOLATILE—A solution of ammonium carbonate in alcohol, containing some free ammonia, and sometimes flavoured with essential oils such as lemon or nutmeg.

SAMARIUM (Sm) **and its Compounds**—Atomic weight, 150·4; sp. gr., 7·8; m.p., about 1,300° to 1,400° C. An extremely rare chemical element (trivalent in character) of the cerium group, occurring in samarskite and some other rare minerals. Its salts include the chloride $SaCl_3 6(H_2O)$, the bromide $SaBr_9$, and the iodide SaI_3. There are two oxides (Sa_2O_3 and Sa_4O_9), the lower oxide and its salts being yellow.

SAMARSKITE—A complex yttrium mineral found in North Carolina and near Miask in the Ilmen Mountains, containing cerium, columbium, samarium, tantalum, uranium, yttrium, etc.; crystal system, No. 4, and sp. gr. about 5·6. Hess and Wells have concluded from their analyses that this mineral consists of two compounds of formulæ approximately Y_2O_3,Nb_2O_5 and $2Y_2O_3,3Nb_2O_5$ (*B.C.A.*, 1930, A, 316).

SAND—Granular, hard, siliceous material, being disintegrated rock in pulverulent form. There are various sands used for industrial purposes, including abrasive sands, bevelling sands, a kind used for casting aluminium and steel, another for use in making asphaltic paving; sands for copper, brass, and bronze moulding; carborundum sands for building and filtration purposes. Some kinds consist almost entirely of silica, and are used in glass-making, the manufacture of porcelain and other wares, etc. An automatic sand-washing machine is described in the *Ind. Chem.*, 1926, ii., 212. (See Glass and Silica.)

SAND-BATH—A laboratory contrivance to secure a fairly easily regulated heat, consisting of an iron saucer containing a thin layer of sand heated from below, on which the vessel to be heated is placed.

SANDAL WOOD (Santal Wood)—The Red Sanderswood, sometimes miscalled sandal wood, being dye wood of the *Pterocarpus santalinus* (N.O. Leguminosæ), a tree indigenous in the East Indies and the tropical parts of Asia, is not the real sandal wood. It is used in India for dyeing silk and cotton, to which it imparts red colours of various hues. The active red colouring matter is named santalin, and can be obtained in fine, small, red crystals insoluble in water, but soluble in alcohol. One formula given to santalin (which is stated to be accompanied by several other colouring matters) is $C_{15}H_{14}O_5$ (Merck). (See Leo Soep (*Analyst*, 1927, **52**, 696); and Dieterle and Leonhardt on the "Constituents of Red Sandal Wood" (*B.C.A.*, 1929, B, 569).)

The genuine sandal wood is obtained from several species of *Santalum* (N.O. Santalaceæ), natives of the E. Indies and tropical islands of the Pacific Ocean. White sandal wood (the commonest kind) comes from the *Santalum album*, which grows in Southern India, Mysore, and Madras.

Sandal-wood oil is the principal essential oil exported from India, the production being chiefly confined to Mysore, and this variety of oil is said to be superior to all others.

The oil distilled by steam under pressure, from the wood of the East Indian *Santalum album* (the content varying from 3·5 to 5·8 per cent.), contains from 93 to 98 per cent. alcohols, including about 70 per cent. santalol (an alcohol of the formula $C_{15}H_{24}O$), and a sesquiterpene named santalene. It is used in perfumery and, medicinally, in the treatment of gonorrhœa. The East Indian oils have a sp. gr. of from 0·973 to 0·985 at 15° C.; opt. rot. $-14°$ to $-21°$ at 20° C.; and ref. ind. 1·5023 to 1·5093 at 20° C.

The West Indian oil has a sp. gr. of 0·960 to 0·976; opt. rot. $+18°$ to $+29°$; and ref. ind. 1·5078 to 1·5096.

The Western Australian oil, from *Fusanus spicatus* R.Br., which is related to the East Indian tree, has a sp. gr. at 15°/15° C. of from 0·957 to 0·972, opt. rot. $-0·25$ to $-0·87$, ref. ind. 1·503 to 1·510, and contains 90 to 95 per cent. total alcohols, of which 40 to 45 per cent. is santalol, with a lævo-rotation up to $-15° 30'$. (See Barwood.)

All these varieties are somewhat thick, spicy in taste, of aromatic odour, and soluble in alcohol, ether, and carbon disulphide.

See K. Venkatesaiya on "West Australian Sandal-Wood Oil"; H. E. Watson (*J.S.C.I.*, 1928, **47**, 322 T); A. R. Penrose (*B.C.A.*, 1929, B, 536); Jones and Smith (*B.C.A.*, 1931, B, 463); Sreenivasaya and Narayana on "Sandal-Seed Oil" (*B.C.A.*, 1931, B, 894); and K. A. Chowdhury on "Sandalwood Substitutes" (*Analyst*, 1932, **57**, 124).

SANDARACH—See Gums and Resins, p. 427.

SANDSTONES—Compacted siliceous stones more or less ferruginous in character, used for building purposes. Sandstone can be converted into a much more concrete and hard condition by impregnation with sulphur. (See Sand and Sulphur, p. 874.)

"SANITAS" FLUID—The aqueous solution of the products resulting from oxidation of terpenes by air, oxygen, or ozone conducted in the presence of water; containing hydrogen dioxide, thymol, and some soluble resinous substances; used as a non-poisonous, oxidizing and bleaching agent, antiseptic and sanitary reagent. Its manufacture resulted from the researches made by the author of this Encyclopædia concerning the atmospheric oxidation of essential oils and their terpenes. (See Hydrocarbons (Terpenes) and Turpentine.)

"SANITAS" OIL—A liquid preparation of air-oxidized terpenes containing camphoric peroxide possessing powerful oxidizing, fumigating, and antiseptic properties; of value for the treatment of lung and throat affections. (See "Sanitas" Fluid and Turpentine.)

SANITATION—See Hygiene.

SANTALIN—See Sandal Wood and Barwood.

"SANTICIZER" (1, 2, and **3)**—Name of a German series of plasticizers for use in cellulose lacquers.

SANTONIN ($C_{15}H_{18}O_3$) is prepared from the dried unexpanded flower-heads of *Artemisia maritima* (Turkestan) or Levant worm-seed, the content being about 2 to 3½ per cent. Other species grow in Cashmere, Mexico, Russia, and Western Thibet, and *A. brevifolia* (India). It is a useful remedy for worms in children, having a specific action on ascarides and lumbricoids, but has no destructive value against tape or thread worm. The drug imported under the name of *santonica* contains but little santonin—from nil to 3·5 per cent. Its industrial preparation is described in an article reproduced in *Ind. Chem.,* 1930, vi., 375.

Santonin is the lactone of santoninic acid; it melts at 170° C., is sublimable, crystallizes from alcohol in pearly plates, and is soluble in chloroform, ether, and hot water. (See Clemo (and others) on the "Constitution of Santonin" (*J.C.S.*, 1929, p. 2368, and 1930, pp. 1110 and 2579); also Wedekind and others (*B.C.A.*, 1930, A, 347) and Worm-seed Oil.)

SAPOGENINS—There are several substances of this class, being hydrolytic derivatives of the saponins; one is named hederagenin, said to occur in ivy leaves and the shells of commercial soap-nuts, to which has been assigned the formula $C_{30}H_{47}(OH)_2.CO_2H$, of m.p. 332° to 334° C. They are stated to be related to one another; also to the sesquiterpenes and to the phytosterols.

The leaves and stems of *Aralia montana* contain about 1·6 per cent. of saponins of several groups, from which *Ariligenin* can be obtained in colourless needles (m.p. 275° C.), said to have the composition $C_{26}H_{42}O_3$ or $OH.C_{25}H_{40}.CO_2H$. Wedekin and Schieke assign the formula $C_{29}H_{46}(OH)(CO_2H)$ to the sapogenin of guaiacum bark (*B.C.A.*, 1931, A, 491). (See Hederin and Saponins.)

SAPONIFICATION—A term used to express the hydrolysis of esters by alkalies, and particularly applied to the hydrolytic action whereby fats

SAPONIFICATION (*Continued*)—

and oils containing glycerides are converted into soaps. The process is believed to take place in three stages, passing from the original triglyceride through diglyceride to the monoglyceride stage, and ultimately to completion. Magnesia is said to be the most effective base in the cases of tallow, palm-kernel acid oils, and whale oils; while lime is superior in the case of palm oil, and both equal in respect of linseed oil. The rates of saponification of various oils, waxes, and triglycerides have been studied by McBain (with others) (*J.C.S.*, 1929, p. 2185); see also *Ind. Chem.*, 1927, iii., 458, Esters, Fats, and Soaps.

SAPONIFICATION VALUES (Numbers)—See Fats, p. 338.

SAPONINS—The constitution of these water-soluble glucosidal substances, which are found in more than 60 families and 400 species of the phanerogamic divisions and some of the cryptograms, are not well ascertained. The formula of one (from the cell-sap of *Agave lechuguilla*) has been given as $C_{27}H_{44}O_{12}$, another (from *Polygala amara*) as $C_{34}H_{52}O_{20}$, and yet another as $C_{32}H_{52}O_{17}$, described as a nearly white inodorous glucoside of great foaming power. One of these compounds is a constituent of common soapwort (*Saponaria officinalis*, N.O. Caryophyllaceæ), *Sarsarparilla quillaya*, and *alfalfa* (lucerne hay).

Saponin can be extracted from the root of soapwort by hot alcohol, and is deposited upon cooling the extract. Its dust excites sneezing, and when dissolved in water and agitated, it makes a frothy solution which is used variously for addition to or substitute for soap; as a foam-producer in the preparation of beverages; for making emulsions with oils; as an agent for increasing the spreading power of sprays upon foliage; in sizing and fire-extinguishing appliances, etc. Upon hydrolysis its saporubin $(C_{18}H_{28}O_{10})_4$ content is stated to yield sugar, and the sapogenin $C_{14}H_{22}O_2$.

Commercial saponin is made by boiling the powdered bark in water, evaporation of the extract to dryness, and extraction of the residue with alcohol, from which solution it deposits, on cooling, as a white powder. In addition to soapwort, various other natural materials are employed in making commercial saponins, including soapberry, panama wood, milkwort, liquorice, etc. (See *Ind. Chem.*, 1929, v., 434, and *C.T.J.*, 1931, **89**, 106.) Saponins are also contained in senega roots (*Polygala senega*), which are largely collected in Minnesota and Manitoba.

The varieties of saponin are said to be divisible into three classes—viz., those precipitable by normal lead acetate, basic lead acetate, and basic lead acetate in presence of ammonia, respectively; that of *Pseudophœnix vinifera* belonging to the third class. (See Quillaya.)

The saponin occurring in lucerne has been credited with the formula $C_{27}H_{37}O_{16}N$, and is poisonous to fish, not by the exercise of any special toxic effect, but by preventing the diffusion of air into the water.

The weak acidic nature of saponin has been attributed to the presence of quillajic acid, which on boiling with weak acids is split up into glucose and insoluble quillajic sapogenin—

$$2C_{19}H_{30}O_{10} + 8H_2O = 4C_6H_{12}O_6 + C_{14}H_{28}O_4.$$

SAPONINS (*Continued*)—

Saponin from quillaya bark yields about 3·1 per cent. sapogenin, and is stated to consist of one-third quillajic acid and two-thirds of a body named sapotoxin.

The sapogenin from soap-nuts (thought to be the fruit of *Sapindus saponaria* L.) is credited with the formula $C_{31}H_{50}O_4$, and said to be identical with hederagenin, the dihydroxy acid from *Hedara helix*. (See Hederin.) The sapogenin of the sugar beet has been formulated as $C_{31}H_{50}O_3$ (A. W. Haar, *B.C.A.*, 1928, A, 68); while a saponin prepared from dried beetroot shavings by K. Rehorst has been assigned the formula $C_{37}H_{56}O_9$ of m.p. 215° to 216° C. (*B.C.A.*, 1929, B, 568); and another from the root of spinach by O. Dafert represented by $C_{42}H_{78}O_{24}$ (*B.C.A.*, 1931, B, 414). Saponin from chestnut seeds is the subject of a paper by A. W. Van der Haar (*B.C.A.*, 1926, p. 522). See also "Value of the Saponins as Foam-Producing Materials," by R. Mand (*Analyst*, 1927, **52**, 42); A. Windaus (*B.C.A.*, 1926, A, 1146; *Ibid.*, 1927, A, 42; and *Ibid.*, 1927, A, 341); A. W. Van der Haar (*B.C.A.*, 1929, A, 1045; and *B.C.A.*, 1930, A, 92); Ruzicka and Van Reen (*B.C.A.*, 1929, A, 1305); S. Aoyama (*B.C.A.*, 1930, A, 1440); A. Winterstein (with others) (*B.C.A.*, 1931, A, 1159); F. G. de Wilde (*Analyst*, 1932, **57**, 180); also Digitalis and Sapogenins.

SAPPAN WOOD—A red wood (*Cæsalpinia sappan*, N.O. Leguminosæ), growing in China, Japan, and Siam, known commercially as brasill and brasilly; used in medicine, dyeing, and calico printing.

SAPPHIRE (Al_2O_3) (crystal system, No. 3, and sp. gr. 4·0)—Blue gems of pure corundum ranking next to the diamond in value, found in Bohemia, Saxony, Ceylon, Cashmere, and Burmah. (See Aluminium.)

SAPROPHYTES—Minute organisms, including yeast cells and various bacteria, capable of inducing processes of fermentation. (See Bacteria, Microbes, and Yeasts.)

SARCINE or HYPOXANTHINE ($C_5H_4N_4O$)—A weak basic body slightly soluble in water, occurring in muscular flesh and nearly related to xanthine ($C_5H_4N_4O_2$). Both are chemically related to uric acid.

SARCOSINE (Methyl-glycocoll) ($C_3H_7NO_2$ or $CH_2.NHCH_3.CO.OH$)—A weak base obtained, together with urea, by the action of baryta water on creatine: $C_4H_9N_3O_2.H_2O = C_3H_7NO_2 + CH_4N_2O$ (urea). (See Cocker and Lapworth on "A Preparation of Sarcosine," *J.C.S.*, 1931, p. 1894.)

SARDINE OIL—See Fish Oils.

SARDONYX—A kind of chalcedony. (See Chalcedony.)

SARSAPARILLA ROOT—The dried roots of *Smilax officinalis* (N.O. Smilaceæ), containing, besides gum and starch, a peculiar substance known under several names, amongst others, sarsaparillin, which can be obtained in a crystalline form from an alcoholic extract of the root. It is very soluble in water, and a decoction of the root is used in

SARSAPARILLA ROOT (*Continued*)—

medicine and in compounding what is known as a "soft drink" in the United States of America.

There are a number of varieties of sarsaparilla obtained from as many varieties of this climbing plant produced in the United States, Costa Rica, British Honduras, Mexico, West Indies, etc.

SASSAFRAS OIL—A yellowish volatile oil distilled (2·6 per cent.) from the bark and root of *Laurus sassafras* (N.O. Lauraceæ), found widely distributed in Canada and N. America, having an odour like that of fennel oil; sp. gr. 1·065 to 1·095 at 15° C., opt. rot. +1° to +4° at 20° C., and ref. ind. 1·525 to 1·530 at 20° C. It is soluble in alcohol and ether, contains 80 to 90 per cent. safrole, together with some eugenol, camphor, pinene, and phellandrene; used in perfumery and medicine, as also in the manufacture of heliotropin, piperonal, etc. (See Safrole.)

SATIN SPAR—A fibrous form of gypsum (calcium sulphate).

"SATRA"—A new polish for patent leather, which has been tested with good results.

SATURATED COMPOUNDS—See Valencies.

SATURATION—See Crystals and Solution.

SAVIN OIL—A nearly colourless essential oil distilled from the twigs and leaves (3·75 per cent.) of *Juniperus sabina* of Canada, Northern Europe, Asia, and America; sp. gr. 0·91 to 0·93 at 15° C., opt. rot. +40° to +60° at 20° C., and ref. ind. 1·474 to 1·477 at 20° C.; soluble in alcohol and ether. It contains a terpene named sabinene ($C_{10}H_{16}$), mixed with the alcoholic body sabinol ($C_{10}H_{15}OH$), and is used in medicine as a stimulant, etc.

SAWDUST is utilized, apart from its value as a packing material, in the manufacture of solvents, cellulose, paper, industrial alcohol, oxalic acid, carbon black. (See *Ind. Chem.*, 1927, iii., 539; Briquetting, "Ketol," and Solvents.)

"SAXIN"—See Saccharin.

SCALES—See Balances.

SCAMMONY—See Gums and Resins, p. 427.

SCANDIUM (Sc) **and its Compounds**—Atomic weight, 45·1, credited with an isotope of mass number 45. A member of the cerium group and one of the rarest chemical elements. It is trivalent and forms the usual salts, including an oxide (Sc_2O_3), bromide ($ScBr_3,3H_2O$), nitrate ($Sc(NO_3)_3.4H_2O$), and sulphate ($Sc_2(SO_4)_36H_2O$), all of which are colourless and soluble in water. Its discovery was predicted from a study of the periodic law of elements.

SCAPOLITES—Natural silicates of aluminium and calcium of crystal system, No. 2, and sp. gr. about 2·6. (See "Constitution of the Scapolites," by L. H. Borgström (*B.C.A.*, 1931, A, 594.)

"SCHAEFFER SALT"—2-naphthol-6-sulphonic acid.

SCHALLERITE—A brown mineral described as of volatile character and composition, $12MnO,9SiO_2,As_2O_5,7H_2O$, alleged to occur in zinc-ore veins in New Jersey.

SCHEELE'S GREEN—See Copper Compounds, p. 240.

SCHEELITE—See Tungsten.

"SCHELLON SOLUTION"—An Austrian synthetic resin product.

SCHISTS—Crystalline rocks of foliated structure, such as Mica-schist and Hornblende-schist; the term is also applied to indurated clay-rocks. (See Shale and Petroleum.)

SCHLIPPE'S SALT ($Na_3SbS_4,9H_2O$)—Sodium thioantimoniate (from which so-called "golden sulphide" (as used in colouring vulcanized rubber goods) is made by decomposing it with dilute sulphuric acid). It is prepared by fusing antimony ore (sulphide) with dry sodium sulphate, charcoal, and sulphur, and concentrating the aqueous extract thereof to the point of crystallization.

"SCHMIEDEL BOX"—See Sulphuric Acid Manufacture (under Sulphur).

SCHÖNITE—A double sulphate of magnesium and potassium found among the Stassfurt deposits.

SCHWEINFURT GREEN (Paris Green)—See Copper Compounds, p. 240.

"SCLERON"—An aluminium alloy resembling "duralumin," but containing lithium partially or entirely in place of magnesium. (See E. Scheuer, *B.C.A.*, 1927, B, 168, and *Ibid.*, B, 880.)

SCLERO-PROTEINS—Insoluble proteins, being constituents of the skeletal parts of certain tissues such as cartilages, ligaments, hoofs, nails, hair, sponge, coral, etc.

SCOPOLAMINE—See Henbane and Hyoscine.

SCOURING—(1) Solvent scouring depends upon the extraction of oily and fatty matters from fibres and fabrics by direct solvent action of benzene, petrol, etc.

(2) Saponification, by conversion of fatty matters into soaps by action of alkali, and removal of these soluble products by solution.

(3) Emulsification, by which greasy dirt is removed mechanically, the frothy lather or emulsion being wetted out.

(4) Attrition or mechanical scouring by fuller's earth, etc.

SCREENING—See Separation.

"SCRIM OIL"—Linoxyn as made in the Walton process of linoleum manufacture.

SCRUBBING—See Gas Washing.

SEA-FOAM—See Meerschaum.

SEA-WATER—See Water.

SEA-WEEDS—There are many species and abundant quantities, some of which are of considerable interest from a chemical point of view. Some kinds are burned for the sake of their alkaline ash, and as a source of bromine and iodine; others being used as articles of food and as fertilizing agents on account of the high percentage of nitrogen they contain. The ordinary sea-wrack is also said to be serviceable for the production of a good paper pulp, but this has been contradicted.

The amount of ash varies from 17·7 per cent. in *F. sercatus* to 52·37 per cent. in the roots of *L. hyperboria*.

Laminaria saccharina contains mannite, and is largely used as food in China and Japan. *Varec* or *vraic* is greatly appreciated in the Channel Islands as a valuable fertilizer, and *duftweed* is extensively used in Ireland as a dressing for potatoes.

Some analytical details concerning the Spanish sea-weed (*Fucus platicarpus*) are given by J. Giral (*B.C.A.*, 1930, A, 259).

Rhodymenia palmata (dulse) and *Alaria esculenta* (murlins) are both used as food in the Scottish Highlands and Ireland.

Chondrus crispus and *C. mamillosus* of the order Florideæ (carrageen, or Irish moss) contain nearly 80 per cent. of a peculiar gelatinous substance named "caregeenin," and some 70 per cent. (on the dry weight) is soluble in water. It serves as a substitute for tragacanth for certain purposes; finds some use as food; is used by painters instead of size; also for making jellies, lozenges, and mucilage; for dressing the warp of webs, for clarifying beer, and for leather dressing. The gelatinizing property is lost by treatment with mild acid hydrolysis.

Gracilaria lichenoides (Ceylon or edible moss) is found in the Indian Archipelago and China, and, together with *Encheuma spinosum,* is used for the preparation of nutrient jelly in bacteriological research, also for gumming silks, paper, etc., and for making soups.

The protein content of sea-weeds (calculated on the dry matter) varies from 9·28 in *Chondrus crispus* to 29·06 per cent. in *Porphyra laciniata,* and the nitrogen content from 1·485 to 4·65 per cent.

Nutritive jellies can be made from several varieties, and a material prepared from them is used to some extent as a substitute for horn, shell, whalebone, etc. A crystalline sugar named *floridose* is obtained as a hydrolytic product from the mucilaginous substance formed by boiling sea-weeds in water.

Sea-weeds are also the source of a binding material for use in briquette making known as the "Thornley Patent Binder." Bladderwrack (*Fucus vesiculosus*) is used as a remedy for obesity and kidney trouble, while a certain variety known as eel grass, gathered from the coasts of Nova Scotia, is now being used as a sound absorber in the construction of offices, hospitals, and houses. (See W. Singleton on "The Utilization of Sea-weeds" (*Ind. Chem.*, 1927, iii., 267); Dillon and Laville (*B.C.A.*, 1929, B, 1043); also Agar-Agar, Algæ, Algin, Alva Marina, Barilla, Iodine, Kelp, and Salsola.)

SEA-WOLF LIVER OIL—See Fish Oils.

SEAL OIL—See Fish Oils.

SEALING WAX—A mixture made by heating together shellac, Venice turpentine, and vermilion (mercuric sulphide); another mixture is that of beeswax and resin. Resin (colophony) is often substituted in part for shellac, and various mineral colouring matters are used in place of vermilion according to the desired colour; for white sealing waxes basic nitrate of bismuth is used, giving a product of a beautiful white enamel-like brilliancy.

SECRETIN—A gland product which stimulates the pancreas and is concerned in the complex process of digestion. One method for its preparation and isolation is described by E. U. Still (*B.C.A.*, 1930, A, 821).

SEED-CRUSHING TRADE—See Oil Cakes.

SELENIDES—Compounds analogous to sulphides found in mineral forms as *benzelianite* or copper selenide (Cu_2SE_3); *clausthalite* or lead selenide (PbSe); *naumannite* or silver selenide (Ag_2Se), etc. (See Selenium; also paper by L. Moser and K. Atynski (*J.C.S. Abs.*, June, 1925, II., 583).)

SELENITE—See Calcium, p. 121.

SELENIUM (Se) **and its Compounds**—Atomic weight 79·2; m.p. 217° C.; b.p. 680° C. An element stated to have six isotopes and nearly resembling sulphur in its general properties. It is found in association therewith in volcanic areas in its free state; also as selenide of sulphur in Swedish pyrites, and in combination with other metals in a number of minerals, including some copper pyrites. Russian selenium has a high reputation for purity, deliveries being found of 99·75 per cent. purity in black amorphous lump form. It is recovered to some extent in the electrolytic refining of copper from the mud that settles in the cells, also from the deposit that is thrown down from sulphuric acid in the chambers and Glover tower, and from the flues of pyrites burners. (See A. Garnak (*B.C.A.*, 1929, B, 813); *C.T.J.*, 1926, **78,** 533); and W. Stahl (*B.C.A.*, 1926, B, 537).) Like sulphur it is allotropic, three varieties at least being known—viz., a vitreous red form, of sp. gr. 4·26, obtained by precipitation; a crystalline red form, of sp. gr. 4·47; and the dark grey or black metallic form which melts at 217° C., and is of sp. gr. 4·80. Of these, the two first named are soluble in carbon disulphide. The heat of transformation of the vitreous variety to the metallic form has been given at 130° as 13·5 cal./g.

The amorphous form is a bad conductor of heat and electricity, while the black, hexagonal, crystalline, metallic variety is a good conductor, and its electrical conductivity is increased by the agency of light. Heated in the air, it burns with a blue flame, forming an oxide and emitting an offensive pungent odour.

The grey selenium is stated to consist of two modifications, one of which exhibits a very high resistance which may rise under certain conditions to 70,000 ohms, and is prepared by heating the metal only just above its melting-point and allowing it to cool slowly. The other

SELENIUM (*Continued*)—

modification has a very small specific resistance, and is obtained by keeping the molten selenium for some time near its boiling-point, and then allowing it to cool.

Selenium is used in wireless telephony, electrical and physical contrivances, in photometry, and as a decolourizing agent in the production of colourless glass, 1 part per 42,000 of glass or 0·0024 per cent. being generally added. Advantage is also taken of its peculiar electrical conductivity when exposed to light in the construction of an instrument termed the "optophone," by means of which the blind can read books through the agency of the telephone.

It has been found that selenium can be economically used to flameproof electric wire, but the quantity required for treating paper, scenery, and other diffuse materials is relatively large.

Two oxides apparently exist: the dioxide (SeO_2) being a white crystalline body which can be sublimated, and dissolves in water to form selenious acid (SeH_2O_3) corresponding to sulphurous acid. The trioxide (SeO_3) has been obtained by the action of ozone on the oxychloride saturated with selenium, as a yellow amorphous substance of density 3·6, which decomposes at about 120° C. without melting, and is soluble in water and alcohol. There is also a selenic acid (SeH_2O_4) corresponding to sulphuric acid. Both selenious and selenic acids can be obtained in crystalline form.

Two chlorides are known—viz., Se_2Cl_2, a brown oily compound which has the property of dissolving metallic selenium, and is slowly decomposed by water; and $SeCl_4$, a pale yellow crystalline volatile substance. There are also two corresponding fluorides.

Hydrogen selenide (SeH_2) is a colourless gas resembling hydrogen sulphide in its odour and chemical properties, obtained by the action of an acid upon a selenide, as, for example, the action of hydrochloric acid upon magnesium selenide.

A claim has been made to the effect that the addition of very small quantities of selenium oxychloride (in common with di-ethyl telluride) to low-grade petrol absolutely prevents the "knocking" of internal combustion engines working at high compression.

Selenium oxychloride ($SeOCl_2$) is a nearly colourless liquid, of b.p. 176·4° at 726 mm., and m.p. 8·5° C. It is a highly corrosive liquid, which readily dissolves selenium, sulphur, and tellurium.

The compounds of selenium resemble those of tellurium in most respects. (See Selenides.)

SEMI-—A prefix indicative of partly or one-half.

"SEMI-STEEL," S.P.M.—A material possessing mechanical properties intermediate between those of cast iron and cast steel, of which filter-press plates and some autoclaves are constructed.

SEMOLINA—A farinaceous food preparation made from the hard-grain wheats of Italy, Spain, and South Russia, containing a relatively large amount of nitrogenous material.

SENEGA ROOT—The dried root of *Polygala senega* of North America, used as a cure for snake bites and making other medicinal preparations. (See J. F. Liverseege, *Analyst,* 1928, **53,** 499.)

SENEGAL GUM—See Gums and Resins, p. 427.

SENNA—A drug made of the leaves or dried fruit of the Alexandrian shrub *Cassia acutifolia* or the Tinnivelly *C. angustifolia.* Various sorts grow in parts of Abyssinia, Barbary, Egypt, Tripoli, the East Indies, and Syria. It contains a number of chemical principles, including emodin and chrysophanic acid. Cathartin is the name given to an infusion of the leaves and pods, used as a cathartic.

"SENSITOL" (Green and Red)—Two substances of dyestuff character used in the production of panchromatic photographs.

SENSITOMETRY—See Photo-chemistry.

"SENSO"—A Chinese drug. (See Toad Poisons.)

SEPARATION—Implies the various means of separating solids from solids, solids from liquids, and immiscible liquids (using in this case separators of a centrifugal character). Engineering appliances such as vibrating screens are used for separating the various particles of dry powders, etc. There are other contrivances such as the "Sturtevant Air-Separator," which picks out the particles of a certain size and allows the others to drop through, the actual size being determined by the speed at which the air current passes through the screen of falling material. There are also various types of sieves, rotary screens, magnetic separators, centrifugal separators, etc., and the B.E.S.A. have now issued a specification for test sieves. A high-speed sifting apparatus ("Blutergess Turbine Sifter") is illustrated (*Ind. Chem.*, 1930, vi., 470). See O. C. Ellington on "A Proposed British Standard Table of Wire Screens" (*J.S.C.I.*, 1926, **45**, 128 T and 353 T); article by A. Ogilvie (*J.S.C.I.*, 1926, **45,** 713 and 735; *Ind. Chem.*, 1927, iii., 568 and 570); *Screening and Grading,* by J. E. Lister (E. Benn, Ltd., London); also Clays, Decantation, Filters, and Magnetic Separation, p. 557.

SEPIA—See Cuttle Fish.

SEPIOLITE—See Meerschaum.

SEPTARIA—Nodules of ironstone or argillaceous limestone, consisting mainly of calcium carbonate in admixture with silica and alumina, used in making Roman cement. (See Cement.)

SEPTIC POISONS—Toxic chemical products produced by bacteria, as in infected wounds. (See Bacteria, Ptomaines, Putrefaction, and Pus.)

SERALBUMIN—Serum albumin. (See Albumins, Blood, Blood Albumin, Proteins, and Serum.)

SERICIN—See Silk.

"SERPEK PROCESS"—See Aluminium (Oxide) and Ores.

SERPENTINE—Mineral forms of hydrated magnesium silicate. Some varieties contain alumina and others iron (crystal system, No. 4).

SERPENTINE (*Continued*)—

The formula $H_2Mg_3Si_2O_8$ fairly represents the composition of many varieties. When heated to 500° to 700° C. it loses most of its water, and the crystal structure becomes that of olivine (H. Haraldsen (*B.C.A.*, 1929, B, 535)).

SERUM—See Blood.

SESAME OIL (Benne Oil, Gingelly Oil)—A fatty non-drying oil expressed to the extent of some 50 to 57 per cent. from the seeds of *Sesamum Indicum* or *S. orientale,* N.O. Bignoniaceæ, indigenous in India, where upwards of 5,000,000 acres are under cultivation; also cultivated throughout the East, and to some extent in the countries of South America. It contains about 38·84 per cent. linolein, 48·61 per cent. olein, and 12·55 per cent. saturated compounds (H. P. Kaufmann, *B.C.A.,* 1926, B, 165-166). The composition has also been given as follows in terms of glycerides: oleic 48·1, linolic 36·8, palmitic 7·7, stearic 4·6, arachidic 0·4, lignoceric trace, and unsaponifiable matter 1·7. Its solidifying point is $-5°$ C.; sp. gr. 0·921 to 0·925; m.p. 26° to 32° C.; i.v. 103 to 114; sap. v. 188 to 193; and ref. ind. n^{20} 1·4731. According to W. Adriani, sesame oil also contains up to about 1 per cent. of sesamin ($C_{20}H_{18}O_6$) and smaller proportions of sesamol ($C_7H_6O_3$) of phenolic odour; and samin ($C_{13}H_{14}O_5$). (See *Analyst,* 1929, **54,** 109.) It is soluble in ether and carbon disulphide, and used for burning in lamps, also for cosmetics, margarine manufacture, soap-making, perfumery, and as an article of food.

Pre-treatment effected by the use of small quantities of "Filter-Cell," followed by the normal refining process, is said to qualify the oil for any purposes to which edible cotton-seed oil can be applied.

SESQUI-—Prefix indicative of proportion 2 to 3: for example, Fe_2O_3.

SESQUIOXIDES—Oxides such as ferric oxide (Fe_2O_3) in which the proportions of metal and oxygen are as two to three.

SESQUITERPENES—See Terpenes.

SEWAGE—The treatment or disposal of sewage necessarily varies with the quantity and quality to be dealt with, the quality being often affected by trade waste materials. Small quantities can be readily disposed of without other treatment by irrigation—that is, distribution over land where sufficient is available—in which case, the natural processes of hydrolysis, nitrification, and oxidation rapidly convert the organic constituents into harmless and vegeto-nutrifying products. (See Irrigation and Nitrification.)

In larger areas, water is employed as a collecting carrier, and in these cases, after sedimentation in tanks with or without chemical treatment, the effluent can, as a rule, be distributed over land, or carried into running rivers, where that disposal is available and unobjectionable. Chemical treatment depends upon the character of the sewage and the trade refuse that may form part of it. Sometimes milk of lime is used; in others, ferrous sulphate or sodium manganate; and in yet others,

SEWAGE (*Continued*)—

powdered coke or breeze or dried peat can be used, the precipitated sediment being disposed of by digging into land, or pressed and used as manurial dressing, or alternatively carried away to sea as sludge containing some 85 per cent. water.

The "Simplex" surface aeration process is carried out by use of a specially designed plant by which agitation and exposure to the air, brought about by a circulating operation, purifies the sewage by the atmospheric oxygen to which it is thus exposed.

For large towns and cities, the purification of sewage is now often carried out in two stages, the first of which employs treatment in what is known as the "septic tank," through which the sewage passes slowly, and in which the heavier solid parts fall to the bottom and are attacked by anaerobic organisms, thus being ultimately liquefied or turned into gaseous products. In the second stage, the dissolved impurities are disposed of by nitrification and oxidation, which are effected by passing the liquid over a large specially constructed filter or "contact" bed when sufficient land is not available. The artificial filters are made of broken clinker or coke, in which cultivated nitrifying and other bacteria carry out the required purification.

More recently, the so-called "activated sludge" process has been introduced, in which the whole purification is completed in a tank charged with a quantity of activated sludge to serve as concentrated carrier of the nitrifying bacteria upon which the purification is mainly dependent, the charge of sewage being subjected to a current of air for several days. It is stated that this sludge of colloidal character containing about 5 per cent. of nitrogen finds a keen demand from farmers. Under favourable conditions, on account of the flocculation of the sewage colloids, which are richer in nitrogen than the gross suspended solids, as much as 30 per cent. of the total sewage nitrogen can be recovered in the sludge. (See report on a discussion concerning activated sewage sludge in *C.T.J.*, 1927, **80**, 7.)

The so-called "bulking" of purified sewage, due to the *carchæsia* and *vorticella* present therein, can, it is stated, be obviated by treatment with certain dyes of the Meldola blue type, these growths being killed by very dilute solutions of the oxazine class. (See Dyes.)

It has been suggested that "in starting a new plant, sufficient activated sludge for the purification of a full charge of sewage could be prepared in a few hours by mixing a thick cream of fine silt or clay with a volume of sewage in which 3 per cent. NaCl has been dissolved." See report of paper by E. C. C. Baly, *Chem. and Ind.*, 1930, **49**, 77, and his later paper on the mechanism of the activated process (*J.S.C.I.*, 1931, **50**, 22 T), in which he describes some new important experiments and discusses the question of the electric charge on the sewage colloids and the bacteria; also report of a paper by F. R. O'Shaughnessy (*Chem. and Ind.*, 1931, **50**, 376).

After the bacterial digestion is completed, the sludge can be pumped, as at Birmingham, over shallow ash-beds, when it readily parts with its water by filtration, without offence.

SEWAGE (*Continued*)—

For the treatment of sewage containing notable quantities of grease, sulphuric acid or, in its place, nitre-cake has been employed, the fatty acids being set free by such treatment, and forming an oily layer on the top, particularly upon the application of heat. Sulphur dioxide has also been used for the same purpose, and exercises an antiseptic effect.

It is computed that 1,000,000 gallons of sewage yields about 1,300 lbs. dry sludge, and that this contains about 90 lbs. nitrogen and 50 lbs. of phosphates, and should therefore have a value well above the cost of drying. The high nitrogen content of activated sewage is attributed in the main to removal of ammonia from the sewage by the formation of amino-acids, due to biological processes connected with the bodies of protozoa.

The Birmingham, Tame, and Rea Drainage Board have profitably installed at Saltley a gas-power plant (using an engine of 400 h.p.) for utilization of the gas produced by an intensive process of fermentation of sewage sludge, the gas being composed of 67 per cent. methane, 30 per cent. carbon dioxide, and 3 per cent. nitrogen, and having a calorific value –625 B.Th.U.s per 1,000 feet.

It is stated that when crude sewage is passed through a filter-bed of straw, the soluble nitrogen compounds are removed from it, so that the effluent becomes comparatively harmless, and the straw itself is thus converted into a valuable manure.

Apart from the question of efficiency in the treatment of sewage, all methods must be regarded from the point of view of economic output. See Kingzett's Patent Specifications Nos. 10,879 and 11,436 of 1885; Jackson and Garner on "Industrial Sewage Disposal" (*Ind. Chem.*, 1931, vii., 76, 101, and 166); W. Butler and J. H. Coste (*J.S.C.I.*, 1927, **46**, 49 T); A. J. V. Underwood on "Filtration Equations for Compressible Sludges" (*J.S.C.I.*, 1928, **47**, 325 T); description of patented rotary pressure filter (*C.T.J.*, 1931, **88**, 158); W. Gavett (*B.C.A.*, 1932, B, 210); *The Principles and Practice of the Dilution Method of Sewage Disposal*, by W. E. Adeney (Cambridge University Press), and other books by H. E. Babbitt (Chapman and Hall); G. B. Kershaw (Cambridge University Press); T. H. P. Veal (Chapman and Hall, Ltd.); A. P. Folwell (Chapman and Hall, Ltd.); C. J. Nurse (Crosby Lockwood and Son); and G. M. Flood (Blackie and Sons, Ltd.); Kjeldahl's Process, Microbes, Nitrification, and Waste.)

"SEXTATE"—A British make of cyclohexanol acetate—a high boiling type of solvent for pyroxylin lacquers and rubber.

"SEXTOL"—A British make of cyclohexanol for use in soap-making.

"SEXTONE"—A British make of cyclohexanone, designed to improve the cleansing power of soap for domestic and textile applications, and for use as a solvent of pyroxylin lacquers. (See Hydrogenation (p. 461) and Hydrogenated Phenols.)

SHALE—A fine-grained rock of silt or clay with a cleavage like that of slate, containing an oil-yielding organic material. It occurs in quantity in

SHALE (*Continued*)—

Scotland, New South Wales (Australia), Nevada, Kentucky, California, Canada, Brunswick, Sweden, and elsewhere, and is often of bituminous or petroleum oil-bearing character. The shale of economic value in Scotland is, however, stated to be nearly exhausted. Deposits are also found in Derbyshire, Dorsetshire, Norfolk, Notts, Somerset (between Watchet and the Parrett), while large deposits of "Tasmanite" exist in the Latrobe district of Tasmania, which yield from 40 to 68 gallons oil per ton.

The oil obtained by distillation of shale (schist) varies in character with different deposits, ammonium sulphate being obtained as a by-product. Normally the organic matter breaks down into paraffin hydrocarbons, phenols, carbon, and gas, and when pressure is used a higher yield of low boiling hydrocarbons is obtained than by ordinary retorting (F. J. Popham). The English deposits are of a low grade, and contain only about from 3 or 4 up to 10 per cent. volatile hydrocarbons, but it is stated that a process of concentration is available, which may render distillation of the product a profitable operation.

The composition of the various deposits of argillaceous nature varies, the ash of the Norfolk Kimmeridge shale, according to Dr. Forbes Leslie, containing 46·10 per cent. silica, 19·90 per cent. alumina, 19·6 per cent. lime, etc.

The oil distilled from Kimmeridge shale (Dorset) is said to be useless as a fuel by reason of its high sulphur content (5 to 8 per cent.), present in the form of thiophene and associated compounds. Some such oils yield to treatment with sulphuric acid, but others with much difficulty. The use of sodium hypochlorite as referred to by A. E. Dunstan holds out a better promise in this report (see his lecture on "The Transmutation of the Chemist" (Institute of Chemistry, December 19, 1930); J. Stewart Remington (*Ind. Chem.*, 1926, ii., 150); F. Challenger (*Ibid.*, ii., 445); and *Chem. and Ind.*, 1929, **48**, 622).

"Kukkersite" (the oil shale of Esthonia, covering some 772 square miles and estimated at 1,500,000,000 tons) is said to be the richest known, having a sp. gr. of from 1·2 to 1·4, the volatile percentage ranging from 52·5 to 65. The deposits yield from 70 to 80 gallons oil of sp. gr. 0·92 to 0·93 per ton by ordinary retorting. This shale, conjectured to be formed from a soft cyanophycean alga, ranks next to the best torbanites in oil content, and rarely contains more than 35 per cent. moisture. The dry shale contains 47 per cent. bitumen—a brown powder of sp. gr. under 1·0—and is marketed in several qualities, the calorific value of average air-dried shale being 9,900 B.Th.U. per lb. (See "Chemistry of Esthonian Shale Oil," by P. Kogerman (*J.S.C.I.*, 1927, **46**, 138 T), and his Monograph, published by the University of Tartu, Esthonia; *B.C.A.*, 1927, B, 354; P. W. Uhlmann (*Ibid.*, 1927, B, 899); and D. von Engelhardt (*B.C.A.*, 1932, B, 216).)

The "Kothla" oil is chiefly used as fuel, but yields light oil and motor spirit upon fractionation, together with a pitch of good quality. About 40 tons of the crude oil is yielded by 200 tons of shale.

The Scottish deposits furnish from 9 up to 22 gallons of oil per ton,

SHALE (*Continued*)—

while many of the large deposits in various parts of the United States and Canada yield from 20 to 80 gallons per ton.

Many oil shales contain small quantities of potash, but so far they have not been worked for its recovery on a paying basis. The organic constituent of shale is known as "kerogen," and can be extracted from the shale by certain solvents, such as aniline, alcohol, and petroleum. This extract is not an oil, but contains bituminous, resinous, and cellulosic substances, and yields oils upon distillation. Shale oil has a bad character as a carcinogenic agent. See E. M. Bailey on "The Refining of Oil Shale" (*C.T.J.*, June 6, 1924); F. Popham (*Ind. Chem.*, 1929, v., 269); and R. H. McKee on *Shale Oil* (Chemical Catalog. Co., Inc., N.Y.); also Naphtha, Petroleum, Schists, and Torbanites.

SHARK OIL—See Fish Oils, p. 353.

SHEA BUTTER—A greenish-white solid vegetable fat from the nuts of *Bassia parkii* or *Butyrospermum parkii* (N.O. Sapotaceæ), containing oleic, palmitic, and stearic acids, and some proportions of a phytosterol and a resin, the content of fat being about 46 per cent. It is obtained by boiling the dried nuts in water and can be deodourized by steam; melts at 45° C., has a sp. gr. of 0·9175, sap. v. 179 to 192, i.v. 56·6, and is used as a lard substitute, chocolate fat, and in candle-making. The fatty acids of the saponifiable portion of shea butter have a m.p. 55·5° C. and i.v. 50·8.

Shea-nut cake is of bitter astringent taste, contains saponin and tannin, and has a moderate value as a feeding-stuff for cattle (see *Bulletin of the Imperial Institute*, vol. xxix., No. 1, 1931).

There are immense forests of the tree which yields this fat, stretching behind the oil-palm belt in West Africa, but its use has been somewhat limited up to the present time by its peculiar rubber-like odour and its variable content of unsaponifiable matter, which ranges up to 10 per cent. (See *C.T.J.*, 1927, **81,** 78; G. de Belsunce (*B.C.A.*, 1927, A, 495); Anon. (*B.C.A.*, 1930, B, 825); and Hopkins and Young (*J.S.C.I.*, 1931, **50,** 389 T).)

SHEEP DIPS—There are a great number of makes, some of the best approved consisting of mixtures made from: (*a*) Carbolic acid, ordinary gas creosote, or other phenolic or cresolic bodies, with soft soap and water; for example, 5 lbs. soft soap dissolved in 3 quarts 97 per cent. carbolic acid and 100 gallons water. (*b*) Flowers of sulphur with slaked lime and water. (*c*) Aqueous extract of offal tobacco. (*d*) Arsenious compounds, alkali, and sulphur worked up with a certain quantity of water. (*e*) Tobacco extract, sulphur, and water in emulsified form. (*f*) Tar oil, tobacco extract, soda-ash, and water, with or without soft soap. (See *C.T.J.*, xlviii., 155, and J. S. Remington on "The Composition and Analysis of Sheep Dips" (*Ind. Chem.*, 1925, i., 525).)

SHEEP MARKING FLUIDS—See *C.T.J.*, 1930, **87,** 377.

SHELLAC—"Stick lac" is either a secretion or excretion of the lac insect (*Coccus lacca*, otherwise *Tachardia lacca*) which abounds in the

SHELLAC (*Continued*)—

forests of Assam, constituting the resinous covering on the branches of various jungle trees, the variety from *Zizyphus xylopyrus* having the greatest moisture content, which ranges from 1·0 to 6·1 per cent. Siam is stated to rank next after India as the world's largest producer. From it is prepared "seed lac"—that is, lac from which the wood has been removed. Lac dye (now obsolete) is the colouring matter of the insect, and shellac is the resin prepared by melting and straining. The sp. gr. of orange shellac is 1·08 to 1·13, acid value about 60, and it decomposes if heated much above 100° C. It is soluble in ammonia and in solutions of sodium carbonate, borax, and other alkalies, certain organic acids, and ketones, while shellac varnish consists of the resin dissolved in alcohol of high-proof character. It is stated to polymerize under heat, as shown by its decreased solubility in alcohol. The Indian production of shellac amounts to some 20,000 tons per annum.

"Garnet lac" is made from the residue left after the squeezing process; "Button lac" is shellac fused in shape of buttons, while "white" or "bleached" shellac is prepared from the orange shellac by dissolving it in dilute sodium carbonate and bleaching with sodium hypochlorite or chlorine solution, thereby destroying the red lac dye. Subsequently the lac is reprecipitated from the solution by sulphuric acid, then washed and kneaded in hot water.

The pure resin is stated to contain from 22 to 24 per cent. of a trioxypalmitic acid named aleuritinic acid, and a yellow dye (erythrolaccen), which gives a red solution with alkalies.

A Burmese lac named "Thitsi" is prepared from the stems of *Melanorrhœa usitato* Wall. Indo-Chinese lac is stated to be tapped from *Rhus succedanea* L. fils, and to contain a substance named laccol, which is readily reduced to hydrolaccol ($C_{23}H_{40}O_2$) of m.p. 63° to 64° C.; this substance in turn being isomeric with hydrothitsiol and a higher homologue of hydrourushiol, which, together with urushiol ($C_{21}H_{32}O_2$), form the main constituents of Japanese lac.

Formosa lac comes from *Semeocarpus vernicifera*, and another product from *Rhus ambigua* Lav., or *Rhus orientalis* Sohn, both containing laccol; whereas Chinese lac (probably from *Rhus vernicifera*) contains mainly urushiol ($C_{21}H_{32}O_2$), which is reported to have a toxic action higher than that of laccol and thitsiol.

In coloured spirituous solution shellac has been advocated as a good ink for marking laboratory glass vessels.

Shellac is the chief constituent of the Indian-made mica-board (micanite) and is used in the process engraving and litho trades, as a stiffening material in the hat trade, in leather-dressing, in electrical apparatus and gramophone record-making, varnishes, and the manufacture of sealing wax, etc.

The so-called synthetic shellac substitutes are mixtures of hydrocarboxylic acids in the form of lactides, and one of these ("albertol shellac") is claimed to be superior to shellac in gloss and hardness, although inferior in elasticity. (See "Shellac Analysis" (*C.T.J.*, 1929, **84**, 485); Technological Paper (No. 232), Bureau of Standards of the

SHELLAC (*Continued*)—

U.S.A. Department of Commerce (*C.T.J.*, October 19, 1923); *J.C.S. Abs.*, 1924, I., 1215; Indian Forest Records, VIII., Part I., 1921; *C. and D.*, 1901, II., 689; 1902, p. 670; 1903, I., 175; and 1905, p. 556; also "Albertol," Lacquer, and Sealing Wax.)

"SHERARDIZING"—See Metals.

SHERINGHAM DAYLIGHT LAMP—See Light, p. 535.

"SHIRLAN" (Salicylanilide)—A new antiseptic introduced with the warp size to protect cotton cloths from mildew effects.

SHODDY—Wool waste and clippings of fabrics, utilized by grinding with toothed rollers, and making up with or without new wool into rugs, inferior cloths, flannels, etc.

SHOVELLING—See Power (Shovelling, p. 731).

"SICALITE"—A kind of French-made plastic material.

SICCATIVES—Agents which promote drying, more particularly the so-called "driers" used in connection with varnishes, oils, and paints, such as manganese borate, resinate, and oleate; cobalt resinate and cobalt linoleate, etc. (See Linseed Oil, Oils, and Varnishes.)

"SICLOR"—An Italian special make of bleaching powder. (See Calcium Compounds, p. 126.)

"SIDERIN YELLOW"—Basic ferric chromate, a pigment used in metallurgy and as a glaze and colouring matter for glass and porcelain.

SIDERITE (**Spathic Iron Ore**)—A mineral carbonate of iron ($FeCO_3$), found in Canada and some of the U.S.A. (crystal system, No. 3, and sp. gr. 3·8).

SIENNA—A yellowish clay coloured by metallic oxides (iron and manganese), used as a pigment. (See Ochre.)

SIFTING PLANT—See Separation.

SILAGE—See Ensilage.

"SILANCA"—Name of a so-called stainless silver so slightly alloyed that it carries the hall-mark. (See Hall Marking.)

SILANES—Silicon Hydrides. (See p. 805.)

SILICA—See Clays, Porcelain, Refractories, Silicon, and Zeolites.

SILICA GELS—See Colloidal Silica, p. 807.

SILICA SOLUTIONS AND GELS—See Colloidal Silica (p. 807), and Colloid Chemistry.

SILICANES—See Silicon, p. 809.

SILICATE OF SODA—See Sodium (Silicate), p. 837.

SILICATES—See Silicon Compounds.

SILICIC ACID—See Silicon Compounds.

SILICIDES—See Silicon Compounds.

SILICON (Si) **and its Compounds**—Atomic weight 28; m.p. 1,420° C.; credited with three isotopes. Silicon is not a metal, but it is known both in the forms of a brown powder and in a crystalline condition of metal-like appearance. Its compounds are abundant and widely distributed in nature. Combined with oxygen as silica (SiO_2), it is found in the forms of *agate, amethyst, chalcedony, cristobalite* (in volcanic rocks), *flint, jasper, onyx, opal, quartz, rock crystal, sand,* and *tridymite,* while in other combinations it helps to make up the composition of clay soil, and many rocks, including beryl, serpentine (a magnesium silicate $Mg_3Si_2O_7$), peridote (another magnesium silicate Mg_2SiO_4), and felspars of varying composition. (See Clay and Zeolites.) Among other forms is found in combination with water ($SiO_2 3H_2O$), in the form of *kieselgühr.* (See T. H. Barry (*Ind. Chem.,* 1928, iv., 226).)

Its three crystalline (polymorphic) forms are known as quartz of sp. gr. 2·65; cristobalite, sp. gr. 2·33; and tridymite, sp. gr. 2·27. The atomic structures of a number of silicate minerals have been worked out by the X-ray method of W. L. Bragg and others. (See Chem. Soc. Annual Report, vol. 26, p. 253.)

To obtain silicon in the free state, several processes are available, in one of which a mixture of potassium-silico-fluoride and metallic potassium is strongly heated, when the potassium replaces the silicon, which is thus set free and obtained by dissolving out the potassium fluoride with water: $K_2SiF_6 + 2K_2 = Si + 6KF$. As thus prepared it is a dark brown amorphous powder with a sp. gr. of from 2·0 to 2·15.

It is obtained in needle-shaped crystalline form by fusing a similar mixture (or replacing the metallic potassium with metallic sodium) with a proportion of metallic zinc, the crystallized silicon being deposited on the zinc, which can be subsequently dissolved out by acid treatment. In this form the silicon is hard enough to scratch glass, has a sp. gr. of about 2·34 to 2·49, and is very insoluble in acids. Exposed to a higher temperature *in vacuo,* it becomes still denser and attains a sp. gr. of 3.

Another process consists in heating quartz with wood charcoal, lime, and manganese oxide in an electric furnace.

Silicon is insoluble in water, hydrochloric and nitric acids, but is soluble in hydrofluoric acid and alkalies.

Silanes—Two compounds of silicon with hydrogen are known—viz., silicon hydride (SiH_4), a colourless gas which is decomposed by alkaline hydrates, giving the corresponding silicates and evolving hydrogen—

$$SiH_4 + 2NaHO + H_2O = SiO(NaO)_2 + 4H_2,$$

and liquid silicon hydride (Si_2H_6), a colourless mobile liquid which is spontaneously inflammable in the air. These compounds, known as *silanes,* are obtained by the action of acid on magnesium silicide.

SILICON (*Continued*)—

Quartz crystals find uses not only as gems, but also for certain optical purposes; while sodium silicate (Na_2SiO_3) as a manufactured article finds many industrial applications. (See Sodium (Silicate).)

Silicon Dioxide or **Silica** (SiO_2) may be prepared in the laboratory in crystalline form or as a white powder by a variety of methods, as when, for example, amorphous silicon is burned in the air. It is fusible in the oxyhydrogen flame, when it melts to a transparent glass-like mass; is insoluble in water, and the only acid that will dissolve it is hydrofluoric acid; it is, however, soluble in alkalies.

It is generally stated that when fused silica is heated above 1,000° C. up to 1,500° C., it is transformed gradually into cristobalite—a change which is completed in several hours after continuing the heat to 1,500° C., and the final product is stated to be probably tridymite: further, that quartz begins to soften at about 1,650° C., and becomes a viscous fluid at from 1,710° to 1,750° C.

The various changes which silica which is stable below 870° C. undergoes upon subjection to varying higher temperatures have been recently studied anew by Smith and Spiers (*Chem. and Ind.*, 1928, **47,** 1278). Above 870° C. it is stated to enter upon a metastable condition gradually changing into tridymite, the change reaching completion in some hours above 1,400° C. but below 1,470° C., but only in the presence of a flux such as sodium tungstate, and at 1,470° C. tridymite is stable. If, however, quartz be heated to 1,250° C. in the absence of a flux, cristobalite formation commences and proceeds with greater velocity at higher temperatures, and at temperatures above 1,470° C. cristobalite is said to be stable, but between that temperature and 1,250° C. it is metastable and slowly changes into tridymite. Tridymite melts at 1,670° C. and cristobalite at 1,710° C. Their paper must be consulted for further detailed information.

Silica is strongly volatile at a temperature slightly above its melting-point, and its use as a substitute for ordinary glass is a developing industry, being acid-proof (although attackable by alkalies and metallic oxides), abraded with difficulty, and exhibiting great resistance to temperature shocks.

The density of transparent fused silica is 2·22, and that of the opaque variety 2·07. Its expansion is less than that of the best glass of the "Pyrex" type, while its crushing strength has been reported as between that of granite and blue brick—*i.e.*, 7 tons per square inch.

Silica of varying qualities is largely used in admixture with paints and rubber articles, also in making soaps, polishes, pottery, phosphorus, non-inflammable materials and packings, as a flux in metallurgy, making silica bricks (quartzites being chiefly used for this particular purpose), and in the manufacture of glass and carborundum.

Silica glass is absolutely insoluble in boiling water, but is permeable to gases at high temperatures, and is an ideal electrical insulating material. (See Burrows Moore on "Fused Silica in Industry" (*Chem. and Ind.*, 1931, **50,** 671); *C.T.J.*, 1926, **79,** 444; and Vitreosil.)

SILICON (*Continued*)—

The enormous quantities of siliceous "sinter" deposited by the geysers at Rotomahama in New Zealand and elsewhere are formed by the action of atmospheric carbon dioxide upon alkaline silicates held in solution by the hot springs, causing the deposition of the silica and the re-formation of an alkaline carbonate. (See "Some Uses of Quartz and Silica Products in Industry," by J. S. Remington (*Ind. Chem.*, 1926, ii., 347); "The Silicate Industries," by W. C. Hancock (*Chem. and Ind.*, 1930, **49,** 1051); and "Silicates in Industry" (*C.T.J.*, 1930, **87,** 273); Ganister and Refractories.

Colloidal Silica results from the decomposition of sodium silicate solutions by acid, and can also be prepared by passing an electric current through a solution of sodium silicate, using diaphragms which permit of the expelled soda being driven out through them in such a way that backward diffusion does not occur. It is thus possible to obtain solutions up to 30 per cent. strength, and these by polymerization give a "gel," which, upon drying, constitutes an inert highly electronegative substance found to have extraordinary powers as an adsorbent for use on wounds. The silicic solution produced by the electro-osmose process is stated at the moment of its preparation to have a molecular weight corresponding to the formula H_2SiO_3. Silica "gels," prepared by several methods, are the subjects of a number of patents, and were used as absorbents during the Great War in gas masks. They are used industrially for the elimination of hydrogen sulphide from gas, the refining of mineral oils (removing the sulphur content), and in the U.S.A. in connection with air conditioning and the iceless refrigeration of railway freight cars. They are also used for the recovery and refining of benzol from coke-oven gases (the gas entering the gel plant under the same conditions as it would enter the oil washers), thus removing the whole of the light oils and any water. Another application is for the dehydration of air for blast furnaces. Some natural siliceous earths of colloidal character are used in some of these applications, such as oil refining. (See *C.T.J.*, October 17, 1924; J. G. Vail (*J.S.C.I.*, 1925, **44,** 214 T); *Chem. and Ind.*, 1927, **46,** 902; H. A. Fels and J. B. Firth (*J.S.C.I.*, 1927, **46,** 39 T); E. H. Lewis (*C.T.J.*, 1927, **81,** 314); *Ind. Chem.*, 1927, iii., 441; *Silica and the Silicates,* by J. A. Audley (Baillière, Tindall and Cox, London); and *Soluble Silicates in Industry,* by J. G. Vail (Chem. Catalog. Co., Inc., N.Y.); and Adsorption, p. 227.)

Silicic Acid ($Si(HO_4)$) is the best-known member of several weak polybasic acids and hydrates which are formed by combination of silicon dioxide with water, and can be obtained either in solution or in gelatinous form, in both of which it behaves as a colloid. The formula $Si(HO_4)$ is attributed to the tertabasic ortho-silicic acid. Preparations of silicic acid, as obtained from various silicates, lose water under the vacuum pump and yield definite silica hydrates. A method of preparing silicic acid similar to that of McGavack and Patrick is described by Jones and Outridge (*J.C.S.*, 1930, p. 1574); see also R. Schwarz (*B.C.A.*, 1926, A, 1112), and Richter and Schwarz (*B.C.A.*, 1927, A, 634).

SILICON (*Continued*)—

Silicon Fluoride (SiF_4) is a colourless, fuming gas prepared by heating a mixture of sulphuric acid, powdered fluorspar, and white sand:

$$2CaF_2 + 2H_2SO_4 + SiO_2 = 2CaSO_4 + 2H_2O + SiF_4.$$

The same compound is formed direct by bringing silicon into contact with fluorine when it takes fire. The gas can be liquefied to a clear colourless state, and when brought into contact with water, decomposition takes place, dibasic silicic acid being precipitated as a gelatinous mass accompanied with hydrofluosilicic acid in solution:

$$3SiF_4 + 3H_2O = 2H_2SiF_6 + H_2SiO_3.$$

Hydrofluosilicic Acid (H_2SiF_6) may also be obtained as a colourless fuming liquid by distilling the gaseous silicon tetrafluoride with water. It is usually put up in the form of a solution of sp. gr. 1·350, although it can be concentrated to a greater extent. It is very corrosive and (in common with fluosilicates) is employed in the ceramic industries, in making concrete floors, certain technical paints, and in solution of some 25 to 30 per cent. strength as an antiseptic and fungicide. Some of the fluosilicates or salts of hydrofluosilicic acid are used to render stonework resistant to atmospheric decay, while others, in common with the free acid itself, are used as insecticides and vermicides. (See article on "Fluosilicates and other Fluorine Compounds as Insecticides and other uses in Industry" (*C.T.J.*, 1926, **78,** 694, and 1928, **83,** 117 and 141); also Fluorine Compounds.)

Silicon Hexachloride (Si_2Cl_6) is formed by passing the vapour of silicon tetrachloride over strongly heated silicon: $3SiCl_4 + Si = 2Si_2Cl_6$. It is a colourless, mobile fluid of b.p. 147°, crystallizes at − 1° C., and, when boiled, its vapour spontaneously ignites in contact with air.

Silicon Tetrachloride ($SiCl_4$) is produced when silicon is heated in a current of chlorine at 500° C. and upwards. The silicon burns and the gaseous tetrachloride is formed direct; or it can be made by passing chlorine gas over a mixture of silica and carbon in an electric furnace (at 1,000° C.), when the following change takes place:

$$SiO_2 + 2C + 2Cl_2 = 2CO + SiCl_4$$

—that is to say, the tetrachloride is produced, attended with the formation of carbon monoxide. The gas can be condensed by cooling, as a colourless liquid which fumes in the air, and is decomposed by water into silicic and hydrochloric acids. Its sp. gr. is 1·524, b.p. 59·6° C., and it was used in the Great War for producing smoke screens.

Silicides—Silicon unites with aluminium, iron, zinc, copper, calcium, magnesium, and some other metals, forming compounds named *silicides*. It also unites with carbon to form the hard crystalline substance silicon carbide (SiC), known otherwise as *carborundum* (see Abrasives), and enters fundamentally into the composition of various kinds of glass which are, in reality, insoluble compound silicates.

SILICON (*Continued*)—

Silicanes—Silicon acts as a substitute for carbon in many organic compounds, and among these are tetramethyl silicane or silicon methyl ($Si(CH_3)_4$), a mobile liquid of light nature, and tetra-ethyl silicane or silicon ethyl ($Si(C_2H_5)_4$), both of which burn with a bright light and emit white clouds of silica. (See Evison and Kipping, *J.C.S.*, 1931, p. 2774.)

Silicon Esters—The name given to the alkyl and aryl silicates and various silicate mixtures; tetramethyl silicane ($Si(CH_3)_4$) and tetra-ethyl silicane ($SiEt_4$) being used, as also the amyl and butyl silicates, industrially. Silicon ester paint medium and stone preservatives are prepared by the controlled hydrolysis of ethyl silicates. (See paper by G. King (*Journ. of the Oil and Colour Chemists' Association*, February, 1930); *Ind. Chem.*, 1930, vi., 112; *C.T.J.*, 1930, **86**, 276 and 315, and **87**, 374; Paints and Stone Preservation.)

Silicon Bronze—An alloy of silicon, copper, and tin used for telegraph and telephone wires.

(See Clays, "Carborundum," Ferro-alloys, Glass, and Sodium (Silicate).)

SILICOSIS—The name of an occupational disease of tubercular character brought about by the inhalation of dust in refractory industries, and metal grinding. The mortality rate in respect of this trouble has been decreased by the substitution of the carborundum wheel for the gritstone wheel. Rules relative to this matter can be obtained from H.M. Stationery Office; see also *Brit. Med. J.*, 1929, September 14, p. 485, and article by G. M. Dyson (*Ind. Chem.*, 1930, vi., 355).

SILK—The fibrous material containing a nitrogenous substance named *sericin* or *fibroin* ($C_3H_7NO_3$), in which the silkworm envelops itself before passing into the chrysalis state. This is coated with a kind of wax which has to be removed in the process of silk-dyeing.

In 1922 the world's production of raw silk was estimated at approximately 32,235,000 kilos.

Stannic chloride is used for weighting silk, the de-gummed fibres being steeped in a solution of that compound and subsequently washed. The recovery of the excess tin is dealt with by G. Butterfield (see *C.T.J.*, 1928, **83**, 384); Goldschmidt and Strauss on "Silk Fibroin" (*B.C.A.*, 1930, A, 940); and *Silk and the Silk Industry*, by J. Schober (Constable and Co., London); also Persoz's Reagent.

SILK SUBSTITUTES ("Artificial Silk," "Rayon")—The name of "Chardone" has been given by France to one of these products, and "Neofil" and "Sniafil" to two Italian productions.

When cotton cloths or yarns, in a stretched condition (so as to prevent shrinking of the fibres), are exposed to the action of a solution of caustic soda of from 18 to 25 per cent. strength a silk-like lustre is imparted to them. The cotton fibres are naturally flattened hollow ribbons or tubes, and under this treatment they swell up, by thicken-

SILK SUBSTITUTES (*Continued*)—

ing, into cylinders without practically any hollow spaces, stronger than the unprepared materials, and more easily susceptible of dyeing. This treatment is known as mercerization, which increases the ripping strain, the weft being less affected than the warp of fabrics made from the prepared material. Any excess of soda is washed out from the mercerized product before use, and in some cases halogenated fatty acids are employed in connection with the mercerization process so as to increase the silky lustre of the products. (See "Action of Caustic Soda on Cellulose," by S. M. Neale (*J.S.C.I.*, 1931, **50,** 177 T); *C.T.J.*, June 5, 1925; "A Contribution to the Theory of Mercerization," by Wood and Alexander (*J.S.C.I.*, 1928, **47,** 357 T); and "The Mercerization of Cotton Goods containing Artificial Silks," by A. J. Hall (*Ind. Chem.*, 1929, v., 355). Mercerized cotton is practically a simple form of silk substitute, and so-called artificial silk can be prepared by passing a solution of this viscose (solution of cellulose or other cellulose derivative) through fine orifices, stretching a number of the filaments thus resulting, and gathering them up together to make a thread.

Unlike real silk, silk substitutes do not contain nitrogen. They are made by several distinct methods, the oldest of which is the so-called nitro-cellulose process (Chardonnet's), in which thick solutions of that substance in a mixture of alcohol and ether were forced by hydraulic presses through capillary glass tubes of very small bore, and the resulting threads twisted on bobbins. As now practised, these bobbins of nitro-cellulose, made from cotton or wood-pulp, are transformed into hanks, which are then subjected to chemical treatment by ammonium, sodium, or calcium sulph-hydrate in order to denitrate them—that is, change the nitro-cellulose into cellulose, thereby suffering a loss in weight of some 35 per cent. This process is still worked in Belgium, but it only accounts for about 3·5 per cent. of the world's production of artificial silk. (See *C.T.J.*, 1926, **79,** 303.)

Thiele silk, which is a French production of long standing, is made by the so-called cupra-ammonium process, conducted by dissolving cellulose (cotton linters or bleached wood-pulp) in ammoniacal cupric oxide solution and forcing the solution through small holes into dilute acid, by which means the copper is removed and regenerated cellulose is precipitated or coagulated as it leaves the spinneret, and after some purification by a "stretch" spinning process yields the finer counts of "artificial silk." This process, however, is little used, only some 4 per cent. of the world's production being obtained thereby.

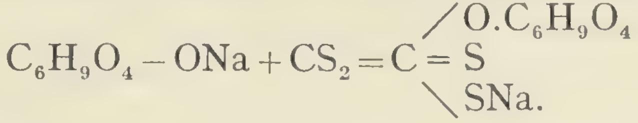
The so-called "viscose" process (using cotton or wood-pulp as raw material) possesses the predominating position in commerce, about 87 per cent. of the total silk substitutes being made on this system. There are other materials from which cellulose can be prepared and utilized by this process, including the residual "begasse" (from the sugar manufacture), Tasmanian stringy-bark pulp (*Eucalyptus obliqua*), and New Zealand hemp fibre, which contains 70·25 per cent. cellulose calculated on the moisture-free material.

SILK SUBSTITUTES (*Continued*)—

Cross and Bevan found that when mercerized cellulose (prepared from spruce or other wood-pulp and bleached cotton linters—that is, "alkali-cellulose" made by treatment of the cellulose with an 18 per cent. of caustic soda solution) is acted upon by carbon disulphide a swollen yellowish mass consisting of the sodium cellulose xanthate is produced. This substance is subsequently dissolved in water or weak caustic soda and treated with sulphuric or other acid, thus effecting the reprecipitation of the cellulose as a gelatinous mass to which the name of "viscose" has been given.

These chemical changes concerning alkali-cellulose can be expressed by the following equations:

(1) $C_6H_{10}O_5 + NaOH = C_6H_9O_4.ONa + H_2O.$

(2) 

$$C_6H_9O_4 - ONa + CS_2 = \overset{\diagup O.C_6H_9O_4}{\underset{\diagdown SNa.}{C = S}}$$

According to Lieser (*B.C.A.*, 1928, B, 742) the pure cellulose xanthate has the formula—$C_6H_{10}O_5,C_6H_9O_4.O.CS.SNa$. The viscose produced as described, after ripening and some purification, is used in the manufacture of "artificial silk" by drawing the coagulated viscose on to bobbins, then washing, drying, sizing, and weaving as required. One ton of sulphite pulp yields about 1,500 lbs. of product. The spinning jets used in manufacturing silk substitutes are made of platinum-iridium or of gold with 10 per cent. platinum. (See Cross, Bevan, and Beadle (*J.S.C.I.*, 1893, p. 498); "Chemistry of Viscose," by Kita and Tomihisa (*B.C.A.*, 1929, B, 809); some notes on its manufacture (*C.T.J.*, 1925, **76,** 605; **77,** 480; and **81,** 320); F. G. Oliver (*Ind. Chem.*, 1926, ii., 152); an American description of the viscose process (*Chem. and Ind.*, 1926, **45,** 925); "Scientific Foundations of the Viscose Process," by E. Heuser and M. Schuster (*B.C.A.*, 1926, **45,** B, 399); "Ripening of Viscose," by M. Numa (*B.C.A.*, 1916, B, 781, and 1927, B, 69); by D. Krüger (*B.C.A.*, 1927, B, 164); "Chemistry of Cellulose, with Special Reference to Rayon," by A. W. Schorger (*J.S.C.I.*, 1930, **49,** 154 T); *Viscose Rayon Production*, by D. L. Pellatt (Emmott and Co., Ltd., Manchester).)

The variety known as "acetyl" silk is made by treating cellulose with acetic acid and acetic anhydride or acetyl chloride in presence of a catalyst such as sulphuric acid or zinc chloride, and the acetylcellulose thus produced containing about 50 per cent. acetyl is spun from an acetone solution in the ordinary manner. This variety consists of cellulose acetate and is stated to approach more nearly to natural silk than any other, and the process is of growing importance.

The swellings and acetylation of cellulose has been studied by Bernoulli (with others) who conclude that the acetylation proceeds in stages—viz., $C_{24}H_{39}O_2Ac$, cellulose monoacetate ($C_6H_9O_5Ac$), and triacetate ($C_6H_9O_5Ac_3$). They also observe that in the case of viscose the affinity for substantive dyes decreases as acetylation proceeds, and dis-

SILK SUBSTITUTES (*Continued*)—

appears altogether at 42 to 44 per cent. (as AcOH). (See *B.C.A.*, 1930, A, 1168.)

According to M. G. Luft, the ageing (ripening) of soda cellulose is accompanied by the conversion of *a*-cellulose into hemi-cellulose, and the different kinds of "artificial silk" may be distinguished by treatment with pure concentrated sulphuric acid and iodine; nitro-cellulose dissolves with a purple colour, cuprammonium silk with a light blue colour, acetate silk with a yellow colour, and viscose silk with a dark blue colour (*B.C.A.*, 1925, B, 984).

By increasing the size of the apertures through which the viscose or cellulose solution is forced, a kind of artificial hair can be produced available for making hats and use in upholstery. Again, by changing the shape of the apertures a straw-like form can be made, and by widening the slit, strips of material are produced, which can be used as a kind of artificial leather or cloth, and as ribbons or sheets. Methods have also been devised in which net and forms of artificial lace can be produced in one operation, or again as a thin wrapping material named "Cellophane."

Viscose dries to a hard, horn-like mass, and is also employed as a substitute for making articles resembling celluloid and ivory, and when mixed with zinc oxide or clay it makes a harder substance called *viscoid*.

The fruit of *Diospyros mollis* is used locally as a black dyeing and weighting material in Siam.

The waterproofing of silk substitutes is effected by several methods, one of which is based upon treatment of the yarn with formaldehyde and lactic acid, and another on treatment with mineral compounds during the desulphurization of the skeins.

Silk substitutes are stated to have a greater affinity for dyestuffs than cotton, and those colours which are most fast on the usual fibres are the most fugitive on the cellulose acetate fibre.

At one time cellulose acetate (acetyl-cellulose) was dyed with direct, vat, and sulphur colours by the addition of caustic soda to the printing pastes, and it was known to possess the property of absorbing some simple primary amino-bases, such as aniline, para-nitraniline, etc., which by various treatments, such as oxidation or diazotizing, gave colouring matter to the fibres. These products, however, were not very satisfactory, but as research work progressed, the use of soluble compounds produced by Green and Saunders from the strongly basic dyestuffs by use of the omega sulphonic acid group (in which the solubilizing acid group is not attached directly to a benzene or fused-benzene nucleus, but to an aliphatic side chain) overcame some of the difficulties previously encountered. This group is split off gradually by hydrolysis in the dyeing operation, thus yielding the actual colouring matter to the fibre, which then readily absorbs it. This method opened up a large possible range of colours, although restricted to amino and ketonic compounds. (See *J. Soc. Dyers and Colourists*, 1923, p. 10.)

For the realization of a fuller range of differently coloured compounds which will hydrolyse within reasonable limits under ordinary working

SILK SUBSTITUTES (*Continued*)—

conditions so as to attain compatibility of dyeing properties while maintaining the requisite fastness of colour, resort was made by G. H. Ellis to other supplementary methods of procedure, now known as the "S.R.A." methods. These rely upon "physical solubilization" or "colloidal dispersion" of ordinarily insoluble colouring matters in such wise as to render them properly available to the fibre to be dyed. The designation "S.R.A." is derived from sulpho-ricinoleic acid—one of the solubilizing agents employed—and the colours are prepared in the form of 10 per cent. pastes which incorporate the colouring matter together with the dispersing agent ready for use. It is also possible, using suitable cotton dyestuffs, to obtain by single bath-dyeing on mixed goods of celanese and cotton or cellulosic artificial silk either totally contrasting shades, blending shades, or uniform effects as may be desired. (See G. Holland Ellis, *J. Soc. Dyers and Colourists,* September, 1924.)

Among dyes which can be used satisfactorily in the dyeing of cellulose acetate are "Duranol" and "Dispersol."

References: "Spinning of Cellulose-Acetate," by A. A. Lautenberg (*Ind. Chem.*, 1932, viii., 50); dyeing and printing of silk substitutes, in four booklets issued by the Imp. Chem. Ind., Ltd.; "The Development of Rayon Dyestuffs," by R. Brightman (*Ind. Chem.*, 1930, vi., 500, and 1931, vii., 3); "Chemical Properties of Commercial Rayon Yarns," by B. P. Ridge (with others) (*Analyst,* 1931, **56,** 270); dyeing of silk substitutes, by G. H. Ellis (*Chem. and Ind.*, 1925, **44,** 1093); E. K. Palmer (*Ind. Chem.*, 1925, i., 133); R. P. Foulds (*Ind. Chem.*, 1926, ii., 147, and 1927, iii. 205 and 273); and E. Clayton (*B.C.A.*, 1931, B, 155); "Finishing," by R. P. Foulds (*Ind. Chem.*, 1927, iii., 291); "A Skin Effect on Viscose Rayon," by J. M. Preston (*J.S.C.I.*, 1931, **50,** 199 T); treatment of viscose silk effluents containing sulphuretted hydrogen (*C.T.J.*, 1929, **84,** 533); methods for reducing the lustre of viscose (*Ibid.*, p. 538); a sketch of the industry, by W. P. Dreaper (*Chem. and Ind.*, 1929, **48,** 111); descriptions of artificial silk works (*Ind. Chem.*, 1928, iv., 449, and 1931, vii., 464); and "Corrosion Problems in the Viscose Silk Industry," by H. R. S. Clotworthy (*Ind. Chem.*, 1930, vi., 445); A. J. Hall (*Ind. Chem.*, 1931, vii., 355, 397, and 508); Artificial Silk Number of *The Times*, March, 9, 1926; *The Rayon Industry,* by M. H. Avram (Constable and Co., N.Y.); *The Manufacture of Artificial Silk,* by E. Wheeler (Chapman and Hall, Ltd.); *Artificial Silk,* by E. Reinthaler, translated by F. M. Rowe (Chapman and Hall, Ltd.); *Acetate Silk and its Dyes,* by Chas. E. Mullin (Constable and Co., Ltd); *Artificial Silk* (*Rayon*)*: Its Manufacture and Uses,* by T. Woodhouse (Sir Isaac Pitman and Sons); Cellulose, Rayon, and "Sniafil."

Apart from the production of silk substitutes from cellulose, patents have been taken out for making varieties from formaldehyde condensation products of urea and cyanamide (see *C.T.J.*, 1929, **85,** 6), while during recent years silk substitutes have been used extensively in combination with cotton materials. The mercerization of such goods by

SILK SUBSTITUTES (*Continued*)—

Marshall's process is described in the article (A. J. Hall's) referred to on p. 810.

The world production of silk substitutes during the first six months of 1930 has been estimated at 91,289 tons, made up of 79,179 tons of the viscose product, 6,675 tons of the acetate, 3,170 tons of the cuprammonium product, and 5,310 tons collodion. Another report gives the British production of Rayon in 1931 as 55,000,000 lbs., and the world's production as 463,000,000 lbs. in 1931.

"SILLAX"—A British make of laboratory porcelain of good quality.

"SILLIMANITE"—A mineral (of which deposits are found in India, at Nongmaweit), being anhydrous aluminium silicate, occurring in crystalline form in gneisses and crystalline schists, while other minerals named *fibrolite, andalusite,* and *cyanite* of distinct physical characters can be converted into *sillimanite* by heating to above 1,320° C. It has valuable properties as a refractory, and it is reported that a stable silicate of crystalline form of the formula $Al_2O_3.SiO_2$ can be prepared by heating china clay (Kaolin) to from 1,200° to 1,300° C. with or without a reducing agent. Brown and Greig have represented that this crystalline body has the composition $3Al_2O_3.2SiO_2$, and they name it "mullite," after the crystals found in some natural rocks at Mull. There has been much divergence of views as to the constitutional changes which occur in clays upon heating. According to J. W. Greig (*J.C.S. Abs.*, October 11, 1925, p. 987), cyanite, andalusite, and sillimanite are all decomposed into mullite and silica, or into mullite and a silicious liquid (probably cristobalite), when sufficiently heated. That mullite is the product resulting from constitutional changes occurring in clays upon heating above 1,050° is borne out by their X-ray diffraction patterns. (See J. F. Hyslop, *B.C.A.*, 1926, B, 157, but M. W. Travers gives 1,545° C. as the temperature at which sillimanite changes into mullite (*Chem. and Ind.*, 1929, **48,** 107).)

Mullite and sillimanite are said to be almost identical crystallographically and optically (W. H. Taylor, *B.C.A.*, 1929, A, 988). Mullite appears to be invariably formed by the interaction of silica and alumina at high temperatures, and can be produced from bauxite, diaspore, gibbsite, and kaolin, or mixtures of them. It exhibits a strong tendency to crystallize, but by careful preparation of "melts" can be prepared of strong character of the approximate composition $3Al_2O_32SiO_2$, strongly resistant to acids and slag action, thus admitting of employment for making bricks less liable to "spalling" than either silica or magnesite brick. (See Sims, Wilson, and Fisher on "Artificial Sillimanite" (*C.T.J.*, 1924, **75,** 419).

Kaolin is stated to break down at 600°, a silicate, presumably $Al_2O_3.SiO_2$, stable up to 900°, being formed, and above this temperature mullite results, which in turn undergoes decomposition above its melting-point (1,810° C.), corundum being formed. (See Kaolin.)

Sillimanite is strong and tough, exhibiting low electrical conductivity, freedom from volume change, of neutral reaction, and resistive

"SILLIMANITE" (*Continued*)—
to corrosive slags, etc. Experimental work has demonstrated that sillimanite is superior to fire-clay for glass-making pots and furnace bricks exposed to great heat, and very useful for repairing the bad places in old furnaces, the best results being obtained with sillimanite bonded with from 10 to 25 per cent. ball-clay. The same mixtures are also used for making semi-permanent moulds for repetition castings in iron, steel, and other metals. (See Silica (p. 806) and Refractories.)

SILO—See Ensilage.

"SILOCEL"—A high temperature insulating material.

SILOXEN ($Si_6O_3H_6$)—An enormously porous substance possessing powerful absorbing quality, prepared from calcium silicide ($CaSi_2$).

SILOXICAN—An amorphous refractory powder, described as a silicon oxy-carbide formed in certain amount in the manufacture of carborundum at temperatures above 1,500° C. It is of general formula $(SiC)_nO$, when n varies from 1 to 7, and can be used for making furnace linings.

"SILUMIN"—An alloy of sp. gr. from 2·5 to 2·65, great hardness and tensile strength (about 12·7 tons per square inch), consisting of about 88 per cent. aluminium and 12 per cent. silicon. It is less attacked by wet steam and strong nitric acid than pure aluminium, is very useful for making steam kettles and similar apparatus, and of great value in the motor industry. (See papers dealing with "silumin" and silicon-aluminium alloys (*B.C.A.*, 1926, B, 831), and Spengler and Wigand on its resistance to corrosion by acid and alkaline solutions (*B.C.A.*, 1931, B, 722).)

SILVER (Argentum, Ag) **and its Compounds**—The atomic weight is now taken as 107·880, but some determinations, made with a very pure silver oxide, gave a mean of $107{\cdot}864 \pm 0{\cdot}0013$ (Riley and Baker, *J.C.S.*, October, 1926, p. 2527). The sp. gr. is 10·5; m.p. 960·5° C., and the metal is stated to have two isotopes with masses of 107 and 109. Silver occurs in nature in the metallic state and in combination in a great number of minerals, including argentite or silver glance, as silver sulphide (Ag_2S); in *horn silver*, as chloride (AgCl); as silver sulphide associated with other metallic sulphides in *pyrargyrite* (Ag_3SbS_3), *stephanite* (Ag_5SbS_4), *proustite* (Ag_3AsS_3); as bromide (AgBr) in *bromite* or *bromyrite*; whilst *iodite* (*iodyrite*) is a Spanish silver iodide of mineral nature containing over 46 per cent. silver. It is present also in many lead ores, notably galena. The world's supply comes from the U.S.A., Canada, Mexico, South America, and Japan. (See also Embolite.)

To obtain metallic silver from argentiferous galena—its chief source—resort is had to the process described as *cupellation*, following upon smelting of the silver ores with lead or materials yielding lead. This process depends upon the fact that the silver can be concentrated into a small portion of lead by crystallization, and then the mixture is exposed to a strong blast of air, thus oxidizing the lead into litharge

SILVER (*Continued*)—

(PbO), which fuses and runs away, or is absorbed by the porous bed of the furnace, leaving the silver behind. The furnace bed is made of bone ash so as to be absorbent, and is known as *cupel*. (See Cupellation.)

In the Mexican amalgamation process, crushed silver ore is ground in water to a state of fine division and, after the incorporation of from 3 to 5 per cent. common salt, spread in a widely distributed manner over a circular space of floor. A day or so later, some metallic mercury is added, together with a proportion of magistral (see Magistral), the whole being well worked up together, and fresh mercury added from time to time. The silver is thus gradually converted into silver chloride, and this, being soluble in sodium chloride, is reduced by the mercury to the metallic state and forms an amalgam therewith. The amalgam is subsequently collected, washed, and subjected to distillation, the mercury passing over and being recovered, while the silver is left behind.

There are a number of other methods which are adapted to the several requirements according to the composition of the ore from which the silver has to be obtained. One of these alternative processes consists of roasting the ore with salt, extracting the silver chloride thus formed with sodium thiosulphate, and precipitating the silver content of the solution as sulphide, from which the metal is obtained by roasting in a reverberatory furnace.

Another depends upon extraction with alkali cyanides and precipitation of the metal by use of zinc or aluminium.

The chloride volatilization process of recovering silver from ores is stated to depend for its success on the maintenance of a sufficient concentration of hydrogen chloride in the furnace, as generated by the action of silica and oxygen, or of sulphur compounds upon the salt added to the charge. The chloride thus formed becomes reduced by certain factors to the metallic state. (See C. M. Bouton (with others), *B.C.A.*, 1925, B, 455.)

The metal can be purified by dissolving it in nitric acid, precipitation therefrom by hydrochloric acid, and after washing the chloride thus formed, dissolving and precipitating with pure zinc. "The Electrolytic Refining of Silver" is the subject of papers by E. Downs (*Chem. and Ind.*, 1927, **46,** 5817, and *Ind. Chem.*, 1929, v., 513).

The small proportion of silver contained in some copper ores is recovered in the wet extraction process by precipitation with zinc iodide. (See Ores, Cyanidation, p. 643.)

Silver is a white metal which is not acted upon by the oxygen of the air, but it has the property of absorbing a large amount of oxygen when in the molten state, most of which is evolved upon cooling; it is dissolved by nitric acid, and is tarnished when sulphuretted hydrogen is present in moist atmosphere, due to the surface formation of silver sulphide. Silver articles deliberately coloured with sulphide are commonly but erroneously described as "oxidized" silver.

There is a stain-resisting silver alloy containing 92·5 per cent. silver which admits of soldering and is readily manipulated.

SILVER (*Continued*)—

Silver is the best-known metallic conductor of heat and electricity, very malleable and ductile, and, when alloyed with copper, is largely used for coinage and other purposes, also for jewellery, table-ware, and electro-plating. Until recently, the British standard for coin was 92½ per cent. silver and 7½ per cent. copper, pure silver being too soft to use alone for this purpose. Silver at its present price finds considerable employment in chemical industries, vessels up to 3 or 4 cwts. being used chiefly for handling acetic acid. It is also available in thin sheet, foil, wire, tube, welded or seamless drawn, and colloidal forms. (See "Silver and its Application to Chemical Plant," by D. McDonald (*Chem. and Ind.*, 1931, **50,** 168); "Colloidal Silver," by G. Gaume (*Analyst*, 1931, **56,** 607); "Recent Research on Sterling Silver," by E. A. Smith (*Chem. and Ind.*, 1929, **48,** 931); and Electro-Plating, p. 292.)

Silver Oxides include a black monoxide (Ag_2O) (insoluble in water), used in polishing glass, produced by the addition of an alkaline hydroxide solution to one of silver nitrate, and which, when dried and heated to 260° C., gives off oxygen and is reduced to the metallic state. It is soluble in strong ammonia, and the solution, on standing, deposits black shining crystals of what is known as *fulminating silver,* an explosive compound believed to be the nitride Ag_2N. (See Nitrides.)

An oxide of the formula Ag_2O_2 has been also described., and G. T. Morgan has described (*J.C.S.,* 1930, p. 2594) certain stable compounds of bivalent silver.

Silver Chloride (AgCl) is white, insoluble in water, but soluble in ammonia, and is used in photography and silver-plating; by action of light it suffers slow decomposition, darkens, and loses chlorine.

Silver Cyanide (AgCN)—A white poisonous powder which decomposes when heated, and is used in medicine. It is insoluble in water, but dissolves in ammonia.

Silver Bromide (AgBr) is pale yellow and less soluble in ammonia, but is soluble in solutions of potassium bromide and cyanide, and is used in photography.

Silver Iodide (AgI) is yellowish, still less soluble in ammonia, but the most stable of the three halogen compounds, and used in photography.

Silver Nitrate ($AgNO_3$) is made by dissolving silver in dilute nitric acid, and crystallization from the evaporated solution. It is the most important soluble silver compound, as, apart from its use in photography, it is used medicinally as a caustic application, also in silver-plating, the looking-glass manufacture, and in the manufacture of an indelible ink for marking linen, etc. It is very soluble in water, crystallizes in large rhombic tables, is partially decomposed at a red heat, giving off oxygen, and is wholly decomposed at a higher temperature, leav-

SILVER (*Continued*)—

ing the metal as a residue. "Lunar caustic" is made by melting the nitrate at about 218° C.

Silver Sulphide (Ag_2S) is formed as a black precipitate by passing hydrogen sulphide gas through solutions of silver salts, and it occurs naturally in the form of *silver glance*. (See Argentite.) It is insoluble in water, and is used in inlaying in "niello" metal work.

Silver Potassium Cyanide ($KAg(CN)_2$) is white, crystalline, soluble in water, and used in silver-plating, etc.

Silver "Salvarsan"—See "Salvarsan."

Many silver compounds are used in photography, and as the chloride is soluble in sodium thiosulphite (hyposulphite), it is extensively used for "fixing" purposes—that is, dissolving out the silver compound that has not been decomposed by the actinic rays. (See Actol.)

"SILVEROID"—A high nickel-copper alloy of great brilliancy containing 45 per cent. copper.

SINAPINE ($C_{16}H_{25}O_6N$)—See Mustard.

SINIGRIN—See Mustard.

SINTER—Incrustation on rocks, etc., deposited from springs of mineral waters. (See Silicon, p. 807.)

SINTERING—Change in crystalline substances due to change in the size of crystals or to formation of allotropes, and formation and growth of crystals in amorphous substances. Sintering in metals and alloys is sometimes caused by the presence of small quantities of molten material between the solid parts. (See Constable on "Sintering of Active Copper Catalysts" (*J.C.S.*, 1927, p. 1578) and description of the "A. I. B." sinter plant (W. E. Simons, *B.C.A.*, 1929, B, 435).)

"SINTERKORUND"—Sintered alumina as a porcelain substitute (*C.T.J.*, 1932, **90**, 256).

SIPHONS—Bent tubes of glass or metal of unequal length for drawing (siphoning) off fluids from one vessel to another over an intermediate elevation (by the agency of atmospheric pressure) to the same level. (See D. C. Harrison (*J.C.S.*, 1927, p. 2896) and H. Wentzel (*Analyst*, **54**, 125).)

"SIRA"—An abrasive prepared by the formula of the British Scientific Instrument Research Association, claimed to be more rapid and economical in use than emery. (See Abrasives.)

SISAL HEMP is obtained from the American aloe (*Agave rigida* or *A. sisalina*) which grows in Yucaton, Mexico, Central America, and the W. Indies, and is cultivated extensively in East Africa, the chief area being in Tanganyika Territory. It is more popular with spinners than Mexican *henequen*, and is valuable for making ship's cables, twine-making, and in upholstery. It is stated, however, that the breaking-strain of sisal hawsers is inferior to that of those made from manilla hemp. (See Hemp and Manilla.)

SIZE—A gelatinous undried form of glue, prepared as a jelly from the third extraction of bones in the making of glue. It is largely used in common with resinous solutions and other adhesives in dyeing and calico-printing, book-binding, paper-making, etc. (See Adhesives, Glue, and Rosin Size.)

SKATOL (C_9H_9N)—A crystalline substance (m.p. 95° C.) found, together with indole, amongst the products of the putrefactive decay of albuminous substances, also in fæces; it occurs also in civet.

SLAG (Dross, Scoria)—For Basic Slag see Concrete (p. 232) and Iron p. 499).

SLAG WOOL (Slagbestos)—See Iron (Slag).

SLATE—A mineral form of silicate of aluminium and magnesium—a kind of argillaceous (clay-like) rock—chiefly obtained from palæozoic strata. In the forms of plates and slabs it is largely used for making school slates and roofing. In a finely pulverized flour-like form it is used as a "filler" of inert character, also in compounding preparations of rubber, paints, pencils, floor-covering compositions, paper, asphaltic mixtures, and so forth. An X-ray analysis of slate is given by Anderson and Chesley (*B.C.A.*, 1931, A, 1146).

SLIP—See Porcelain (p. 722).

SLUDGES—See Sewage.

SMALT—See Cobalt.

SMALTINE (Smaltite), (crystal system, No. 1, and sp. gr. 6·5 to 7·2)—See Cobalt.

SMITHSONITE—Mineral silicate of zinc, $2ZnO,SiO_2,H_2O$, of crystal system, No. 4, and sp. gr. 3·16 to 3·50. (See Zinc.)

SMOKE arises from imperfect combustion of fuel in domestic grates, boiler furnaces, brick kilns, and in certain process operations; that from domestic grates and boiler furnaces containing more or less tarry substances and soot. The thick dark fogs of London and other industrial areas are largely due to the replacement of water particles by smoke, the annual solids falling in the London area amounting to about 461 tons per square mile. (See "Measuring the Smoke Pollution of City Air," by J. S. Owens (*Analyst*, 1926, **51,** 2); R. W. Gray (*Chem. and Ind.*, 1929, **48,** 1071); W. E. Gibbs (*B.C.A.*, 1930, B, 1007); *The Smoke Problem of Great Cities,* by N. F. Shaw and J. S. Owens (Constable and Co., London); *Smoke: a Study of Town Air,* by J. B. Cohen and A. G. Ruston (E. Arnold and Co., London); *Clouds and Smoke,* by W. E. Gibbs (J. and A. Churchill, London); and the Reports of the Advisory Committee of Atmospheric Pollution (H.M. Stationery Office); also Air and Gases.)

"SMOKE BLACK"—Carbon, said to contain 99·75 per cent. as compared with 97·8 per cent. for the best American carbon black, having

"SMOKE BLACK" (*Continued*)—
good decolourizing properties, and used as a pigment for paints, inks, rubber, etc.

SMOKELESS FUELS—See Fuel (Smokeless).

SNAKE POISON—See D. N. Chatterji (*Analyst*, 1930, **55**, 683).

"SNIAFIL"—An Italian product chemically analogous to viscose silk; claimed to possess a higher strength and better lustre than real wool, for which it is a substitute, being essentially cellulose, and differing only from viscose silk in the subsequent treatment of the viscose solution.

SO_2 RECORDER—See Recorders and Sulphur (Oxides).

SOAPS—Combinations or salts of fatty acids with alkali. (See Saponification.)

Hard Soaps are made from the harder fats, such as tallow, mutton fat, palm, palm kernel, cocoa-nut, cotton-seed, soya-bean, and hydrogenated oils, etc., with or without the addition of from 5 to 10 per cent. rosin (which also combines with alkali) by boiling with caustic soda lye of sp. gr. 1·05, the soap, after decolourization with sodium hydrosulphite (if necessary), being afterwards "salted" out by the addition of common salt, which renders it insoluble. This action of salt in graining-out soap consists of its conversion into fibres, etc., of a comparatively low degree of hydration. 1,000 lbs. fat yield about 2,000 lbs. soap lye containing about 5 per cent. glycerol and 10 per cent. mineral salts. After withdrawing the spent lye—from which glycerol (glycerine) is obtained—the soap is solidified in rectangular iron frames or "soap coolers," hardened (dried) by keeping, and then cut up into slabs and bars by means of wires. It has been shown by intensified microscopic examination that most soaps are built up of anisotropic constituents—that is, crystals, crystalline fluids, viscous fluids, syrup, fibres, solutions, and (sometimes) gels. An investigation by McBain and Hay supports the conception that soap solutions are crystalloidal when sufficiently dilute, and colloidal in higher concentrations (*J.C.S.*, 1929, p. 601).

The "Autoclave" process and "Twitchell" process for fat splitting, etc., are described under the heading of Fats (pp. 335-336).

Attempts have been made, with more or less success, to introduce colloidal clay (made from china clay) into soaps to the extent of from 15 to 20 per cent., and claims have been made that some of the products exhibit superior lathering and detergent properties as compared with soaps devoid of this material.

The use of even 5 per cent. rosin will impart a perceptible yellow tint to white goods washed with soap containing that amount, but it possesses the advantage of giving the soap a firmer consistence.

Before the Great War some 110,000 tons of hardened (hydrogenated) oils (of which about 30,000 tons consisted of whale oils) were used annually in soap-making, but for economical reasons much smaller quantities of hardened oils are now employed.

McBain and Stewart have prepared an acid soap, being a definite

SOAPS (*Continued*)—

crystalline, anhydrous potassium-hydrogen dioleate (*J.C.S.*, 1927, p. 1392).

Recently a process of washing has been introduced consisting of immersion of fabrics in a dilute aqueous emulsion of fatty acids (preferably oleine), the emulsion being stabilized by addition of turkey-red oil or other suitable material and treatment of the impregnated material with dilute alkali, preferably sodium carbonate, thus generating the soap *in situ*. (See *C.T.J.*, 1930, **87**, 454, and 1932, **90**, 50, 51, and 61.)

The use of hydrogenated phenols for increasing the cleansing power of soaps is referred to elsewhere. (See Hexalin, Hydrogenation (p. 461), Hydrogenated Phenols, and "Sextate.")

Castile Soap is a hard soap used for making pills and plasters, made from olive oil and caustic soda.

Silicated Soaps are otherwise ordinary soaps into which a proportion of an alkaline silicate is introduced, as these substances, like true soaps, have the property of liberating alkali when dissolved in water. The statement has been made that silicate is not a detergent *per se*, but that it functions as such with greasy substances.

The introduction of silicate, however, permits of the use of oils which melt at low temperature, and thus yields soap containing a large proportion of sodium oleate, which will not dissolve too readily in use; it also improves the emulsifying power, so that altogether sodium silicate is not a mere filler or adulterant; moreover, soaps containing silicate are not so liable to "bloom." The sodium silicate is prepared by fluxing clean sand and soda ash (sodium carbonate) in certain proportions, and for the potassium silicate (used for incorporation with soft soaps) potassium carbonate is substituted for the soda ash.

Ethanolamine Soaps are combinations of certain organic bases—derivates of ammonia in which the hydrogen atoms may be more or less or entirely replaced by the ethanol residue, $CH_2.CH_2OH$—with fatty acids. These ethanolamines are made from ethylene glycol by reaction with ammonia, and solutions of the ethanolamine soaps are good detergent agents which find use in cases where ordinary soaps cannot be used or are ineffective. (See Rex Furness, *Ind. Chem.*, 1930, vi., 24) and P. I. Smith (*B.C.A.*, 1932, B, 193).)

Mottled Soaps are produced by adding to the nearly finished hard soap mass crude soda liquor containing some sodium sulphide, from a watering-pot. In this way, any iron that may be present in the soap combines with the sulphur of the sulphide to form iron sulphide, which makes its appearance in streaks or veins. In some cases a little ferrous sulphate is added to the soap during the boiling, and this becomes decomposed, forming first of all ferrous oxide and then ferric oxide, thus mottling the soap in a marked degree. Again, in other cases "mottling" is produced by the addition of Prussian blue or ultramarine, but the practice serves no useful purpose.

SOAPS (*Continued*)—

Soft Soaps are made chiefly from linseed, castor, cotton, and other seed and fish oils, tallow or resin being at times incorporated in certain proportions for stiffening purposes, while potash lye is used as the saponifying agent. Potash lye, however, is not indispensable, as good soft soap can be made by the use of mixed olein stock, resin, and caustic soda. In some cases the glycerol is left in the soap, which is heated and stirred until it "talks," during which operation much of the water is evaporated, after which it is ready for packing. In other cases the glycerol is removed from the soap by chemical processes. (See Glycerol.)

Toilet Soaps are made of hard soap of various qualities, perfumed or impregnated with mild essential oils, or any other suitable materials, such as terpineol, bromstyrol, benzaldehyde, benzyl acetate, diphenyl, methane, etc., appropriately dried, sometimes milled and ribboned, and then suitably moulded into tablets. An ideal fat base for toilet soap is stated to be made of 80 per cent. good tallow and 20 per cent. good cocoa-nut oil. The transparent character of certain varieties is obtained by the addition of sugar, honey, or alcohol, while opacity can be obtained by the incorporation of ½ per cent. zinc oxide.

Among colouring materials used for toilet soaps may be mentioned Rhodamine B, Xylene Blue, and Tartrazine.

Hard soaps contain from 11 to 69 per cent. of fat acids, the better qualities containing about 62 per cent. and upwards (see references to a paper by F. H. Terleski, *C.T.J.*, 1929, **84**, 213 and 441); soft soaps from 40 to 45 per cent. fat acids, and good toilet soaps from 60 to 70 per cent.

Textile Soaps should not contain above 30 per cent. water, 1 per cent. free sodium carbonate, and be devoid of caustic soda, silicate, and rosin.

Metallic Soaps include the stearates, palmitates, and oleates of aluminium, ammonium, antimony, arsenic, barium, bismuth, cadmium, calcium, chromium, cobalt, copper, iron (ferrous and ferric), lead, lithium, magnesium, mercury (mercurous and mercuric), silver, strontium, tin, and zinc, many of which are used industrially in waterproofing processes; some as vehicles for medicinal salves, plasters, and ointments; also in making lubricating and fungicidal preparations, antifouling paint and varnish driers, and in laundering and dry cleaning.

Their successful use in most cases depends on their colloidal condition, and fats such as lanolin and beeswax have a stabilizing effect on colloidal metallic soap solutions. Heat, dry air, and violet rays tend to destroy their colloidal state, and reduce them to a dusty condition.

Their waterproofing value is due to their capability of absorbing water, thus swelling up and filling the pores of the subject material. (See Whitmore and Lauro on "The Uses, Preparation, and Properties

SOAPS (*Continued*)—

of Metallic Soaps" (*Ind. Eng. Chem.*, 1930, **22**, 646) and E. Markowitz on "Aluminium Soaps" (*B.C.A.*, 1929, B, 101).)

The aluminium, magnesium, and calcium soaps of the stearic series are stated to be superior as heat-proofing insulating materials.

Soap Films.—Films and bubbles when first formed are thick and colourless and all liquid films thin. In his book on Soap Films (G. Bell and Sons, Ltd., London), A. S. C. Lawrence states that "the fundamental change is the thinning (which at first produces the pink and green bands, and all the purer colours of Newton's scale which gradually disappear on further thinning), and this process ultimately results in the formation of the so-called 'black spot.'" He concludes that the "critical fall consists of a gradual breakdown of one of the surface layers; coalescence of the liquid film on the remaining surface layer following as a matter of course." Black appears at a number of points and spreads all over the film, and he regards the "black spot" as the thinnest possible film and the only stable one.

From investigation, P. J. Fryer arrived at the conclusion that "the velocity of saponification of oils and fats, from the point of view of the amount of free alkali removed from the reacting solution, is in inverse ratio to the saponification equivalent or to the mean molecular weight of fatty acids" of their glycerides.

It has been proposed to make soap by first of all saponifying fatty acids with strong ammonia liquor at ordinary temperatures and subsequently decomposing the gelatinous product by means of common salt, and if ever ammonia can be produced sufficiently cheap, this process might be commercially employed to advantage, as both the ammonia and the salt can be easily recovered for use over again.

Many factors, such as wetting, lubrication, deflocculation, lathering, and solution, are involved in the detergent action of soap, but it is chiefly attributable to its power of dissolving and emulsifying oil (including paraffin oil), thus producing soluble compounds or emulsified mixtures readily removable by water.

Sodium naphthenate, made from naphthenic acid (of b.p. 195° to 200° 10 mm.), is stated to possess lathering and detergent powers but slightly inferior to those of ordinary soap in respect of which, according to S. U. Pickering (*J.S.C.I.*, 1917, p. 462), the more concentrated the soap solution, the greater is its solvent action per unit of soap.

By a slight alteration of conditions, the detergent action of a soap may be greatly increased, and under certain circumstances a very slight addition of either acid or alkali enhances it. (See P. H. Fall on "Detergent Action of Soaps," *B.C.A.*, 1927, B, 727.)

Experiments made at Cornell University appear to show that a solution of ordinary hard soap is as effective in preserving eggs as one of water-glass containing the same amount of sodium.

Soap solutions possess a high degree of electrical conductivity both in dilute and concentrated solutions.

See article on "Technology of Soap Manufacture" (*C.T.J.*, December 5, 1924); J. W. McBain and others on "The Equilibria underlying

SOAPS (*Continued*)—
the Soap-Boiling Process" (*J.C.S.*, 1925, cxxvii., 852, and 1926, p. 421); G. P. Vincent on "Detergent Action" (*B.C.A.*, 1927, B, 970); Rex Furness on "The Industry in 1928" (*Ind. Chem.*, 1929, v., 15); in 1930 (*Ibid.*, 1931, vii., 13); and in 1931 (*Ibid.*, 1932, viii., 20); H. M. Langton on "Modern Developments in Soap Manufacture" (*Ind. Chem.*, 1929, v., 65 and 105); *Soap and Glycerine Manufacture*, by E. T. Webb (Davis Bros., 265, Strand, London); also Fats.

SOAP BARK—See Quillaya.

SOAP-STONE ($H_2Mg_3Si_4O_{12}$)—A massive variety of talc, being a hydrous silicate of magnesia, largely used in the form of sawn blocks and bricks for building the furnaces used in the method of recovery of the alkali from sulphate paper-mills in Canada, etc. (See French Chalk, Steatite, and Talc.)

SOAPWORT (*Saponaria officinalis*)—Used in medicine for scrofula and skin trouble. (See Saponins.)

SOBREROL ($C_{10}H_{16}(OH)_2$)—A crystalline compound formed when American turpentine or pinene (a terpene) is left exposed to sunlight in contact with air and water; m.p. 150° C. (See Pinene.)

SODA—See Sodium Compounds.

SODA ALUM—See Aluminium (Alums), p. 39.

SODA ASH—Crude sodium carbonate.

SODA LIME—A reagent used in making nitrogen determinations in organic analyses; also for the absorption of various acid gases, such as phosgene, in military operations. It consists of caustic soda and quicklime, and is made by moistening a mixture of the two ingredients with a solution of caustic soda and drying the mixture. (See "Sofnol.")

SODAMIDE (NH_2Na) is obtained by passing dry ammonia gas over molten sodium at 300° C. in the absence of air. It melts at 155°, is decomposed by water, and finds use as a powerful dehydrating agent in processes for the synthetic production of indigo from aniline and the manufacture of sodium cyanide. (See *Ind. Chem.*, 1927, iii., 327.)

SODA NITRE—See Caliche and Sodium Compounds.

"SODA OLEIN"—See Turkey-red Oil.

SODIUM (Natrium, Na) **and its Compounds**—One of the alkali group of metals; atomic weight, 23; sp. gr., 0·9712; m.p., 97·5° C.; b.p., 877·5° C.

The Siberian lake Petuchow is stated to contain large quantities of sodium carbonate, and at Lake Magadi in British East Africa there exists a vast and remarkable deposit of natural crystalline sesquicarbonate of soda, estimated at 200,000,000 tons of soda (free from sulphur impurities). It is stated to contain sodium salts to the extent

SODIUM (*Continued*)—

of 40·38 per cent. when calculated as Na_2O, and this upon the calcined product amounts to 58·08 per cent., or 99·3 per cent. dry soda ash (Na_2Co_3). (See Magadi Soda.)

The chloride (common salt, NaCl) is a constituent of sea-water, which contains an average of about 28 parts per 1,000. Salt also occurs naturally in large deposits in Cheshire, Lancashire, Worcestershire, Poland, Saskatchewan (Canada), and some lakes in China and elsewhere. In the areas of Winsford and Northwich there are two layers of salt separated by about 30 feet of hard marl, each of about 80 feet thickness, the top one occurring at a depth of 120 to 130 feet below the surface.

The nitrate ($NaNO_3$) is the principal constituent of *caliche* or *soda nitre,* which is found in large quantities in Chile and Peru, and exported to the extent of some 2,000,000 tons annually, having great value as a fertilizing agent on account of its richness in nitrogen. (See Caliche.)

Metallic Sodium is now made in large quantity by the electrolysis of fused caustic soda at a temperature of about 20° C. above its melting-point, and by the electrolysis of fused sodium chloride, using a cathode of molten lead, and subsequent electrolysis of the sodium-lead alloy thus produced. In the electrolysis of caustic soda, the metallic sodium and hydrogen are liberated at the cathode and oxygen at the anode. It can also be made by the electrolytic-amalgam process as described under the heading of Potassium.

It is a light, soft, silver-like metal, and on account of its ready oxidizability has to be preserved in kerosene or naphtha, although it is not affected by perfectly dry air or oxygen. It is used largely in other manufactures, including that of indigo as made synthetically.

Metallic sodium is very like potassium in most respects and decomposes water with considerable violence on being thrown into it ($Na_2 + H_2O = Na_2O + H_2$), the Na_2O, or sodium oxide, thus formed dissolving in the excess of water and forming sodium hydroxide or caustic soda (NaHO) solution.

Sodium Chloride, from sea-water (in association with the other saline constituents), is still made to some extent in Turks Island (British Caicos group) and other Eastern parts in an impure, coarse form by the evaporation of the water in shallow cavities on sea-beaches, the product being known as "solar salt," and used for fish-curing. (See Brine.)

Mining of salt in Cheshire has been practically superseded by brine pumping and evaporation, as this method separates insoluble impurities and gives ease of transport. By varying the temperature of evaporation and by supplying suitable additional agents, salt is produced to suit various industrial demands in the respective forms of "fishery" salt of coarse grain, "bay" salt of still coarser grain, and "butter" salt of fine soft grain. Meat canners require it in finely granulated form, and flour millers in even more finely ground condition, while

SODIUM (*Continued*)—

1 per cent. of a filler is added to table salt to prevent caking. (See C. G. Smith (*Chem. and Ind.*, 1929, **48**, 85.)

Sodium chloride melts at 803·4° C., is very soluble in water, and, apart from the enormous quantities used in the alkali trade, it is largely used for "salting" out soaps; also as a food preservative, fertilizer, in the ceramic industries, in dyeing and calico-printing, glazing earthenware and firebricks, etc.

Rock salt (crystal system, No. 1) varies in composition according to the extent of admixed marl, but contains on average about 95 per cent. of chloride, and, as such, is used for preserving hides and for feeding live-stocks, etc. (See M. Kaye on "Preservation of Hides with Brine and Salt" (*J.S.C.I.*, 1929, **48**, 141 T).)

Direct evaporation of Cheshire brine yields a salt containing about 98·5 per cent. NaCl, while for edible use it is prepared free from calcium and magnesium salts, and little short of 100 per cent. purity.

"Vacuum" salt is made by boiling brine under vacuum as distinct from "pan" salt made by diffusive evaporation, and consists of small uniform crystals of solid pure character, being practically free from mother-liquor, whereas the "pan" crystals, being partially hollow, contain some mother-liquor. Vacuum pans are generally run in connection with power plants, the exhaust steam being used for effecting evaporation.

The world's production of salt in 1920 was reported at about 18,700,000 tons, of which about 2,248,000 were produced in the United Kingdom, and there is a considerable industry in Cochin-China and Canada; but the U.S.A. is the largest producer, its average yearly output being now about 6,000,000 tons.

Caustic Soda (NaHO) (m.p. 318° C.) is largely manufactured for use in many chemical applications, especially in the making of soap, being capable of decomposing fats and oils, thus liberating glycerol, and combining with the fatty acids (their other constituents). (See Soaps.)

Some caustic soda is still made indirectly from common salt by various chemical processes, and in particular by treatment of crude sodium carbonate with lime, the liquors being thus "causticized" and attended with the production of calcium carbonate as a by-product, after separation from which the liquor is either evaporated down to a strength of 90° Tw. for soap-making or further to a state of fusion.

In Germany a good deal of hydrated soda is incidentally produced in the manufacture of pure alumina by the alkaline decomposition of bauxite.

In the "Ferrite" process, soda-ash, in admixture with ferric oxide, is roasted at red-heat, thus producing sodium ferrite with evolution of carbon dioxide, and by lixiviation with water the molten ferrite is hydrolysed, thus producing strong caustic soda in solution and regenerating ferric oxide for use over again.

It is now, however, chiefly manufactured by a process involving the electrolysis of a strong solution of brine (common salt), which produces chlorine at the anode and sodium hydroxide at the cathode. There are a

SODIUM (*Continued*)—

number of cell types, including the "Castner-Kellner" mercury type, the "Bell" type (used in Australia), the "Allen-Moore," the "Wheeler," the fused electrolyte type, and the "Gibbs diaphragm" type. The efficiency of the various cells varies greatly according to the different operating conditions. The first essential is the use of a saturated solution of sodium chloride devoid as far as possible of impurities, and the products in each case are identical—viz., chlorine, hydrogen, and caustic soda. The greater the concentration of OH ions, the more the chlorine liberated, uniting with them to form hypochlorous acid and (eventually) sodium hypochlorite. The favourite type of evaporator is that which works under vacuum, heated by exhaust steam from power plant; weak liquor from the cells can thus be concentrated to about 1·45 sp. gr., and on cooling and settling in large tanks the salt settles out, and a clear, fairly pure liquor is run off, to be further concentrated in finishing pots and solidified. It is understood that a decomposition efficiency above 50 per cent. cannot be economically obtained by this electrolytic process. The chlorine generated in electrolytic processes as above described can be utilized in the manufacture of bleaching-powder or condensed and liquefied. (See B. E. F. Rhodin (*J.S.C.I.*, 1902, p. 449); *Ind. Chem.*, 1930, vi., 485; and for further reference to Electrolytic cells see Chlorine (p. 184) and Electricity (p. 291).)

It is reported that an anode of lead alloy containing from 60 to 80 per cent. silver shows improvement over all others for the electrolysis of brine.

In connection with electrolytic-alkali production, Mr. C. Elliott has prepared a chart (see *C.T.J.*, September 19, 1924) by means of which the operator of any type of cell may read off quickly and directly values which otherwise entail much calculation. The amperage and voltage of the current passing through the cell are read off and the alkali content of the cell effluent is determined, and from these three factors, the current efficiency, the energy efficiency, and the number of kilowatt hours per kilo of caustic produced, can at once be obtained from the diagram. (See *C.T.J.*, July 11, 1924, and a succession of following numbers concluding with December 2, 1924.)

By another process the solution of sodium hydroxide is made to encounter a stream of steam and carbon dioxide, and thus converted into sodium carbonate, which is washed away in solution, and concentrated by heat to the point of crystallization, or converted into caustic soda by treatment with lime.

It is worthy of note that a solution of sodium sulphate in water of 40 per cent. strength can by electrolysis be resolved to a large extent into caustic soda and sulphuric acid, thus obtaining sodium bisulphate (which can be crystallized out with the undecomposed ordinary sulphate), leaving the first-named product in solution.

A cyclic process for the production of caustic soda dependent upon the interaction of sodium fluoride and calcium hydroxide ($2NaF + Ca(OH)_2 = 2NaOH + CaF_2$) is described (*C.T.J.*, 1929, **84,** 201).

Caustic soda is a white, highly deliquescent, caustic substance, and

SODIUM (*Continued*)—

is marketed in several forms—"ground," "flake," "detached," and "stick"—and of varying degrees of purity and strength, suited to its several applications. These also include a practically pure variety in liquor form of 90° Tw. strength; solid forms of from 60 to 76 per cent.; powder form of from 77 to 78 per cent. (in terms of Na_2O); and a crude form containing from 40 to 42 per cent. (in terms of Na_2O).

An account of the Canadian salt-lake deposits is given (*C.T.J.*, **49**, 41), and that of "The Canadian Salt Company's Processes for the Manufacture of Alkali-Chlorine Products" from salt by D. A. Pritchard and G. E. Gallop (*Chem. and Ind.*, 1925, **44**, 220, and some following numbers); see also J. B. C. Kershaw (*Ind. Chem.*, 1925, i., 283).

Sodium Oxides—Sodium monoxide (Na_2O) is a white amorphous body produced from the metal when partially oxidized by a limited supply of oxygen, the excess of metal being subsequently distilled off *in vacuo*.

Sodium peroxide (Na_2O_2) results from the burning of metallic sodium in oxygen, and is commercially made by passing purified dry air over metallic sodium placed on trays of aluminium at a temperature of 300° C. It is a nearly white substance of considerable commercial importance, owing to the fact that in contact with water or dilute acids it decomposes, yielding hydrogen peroxide in solution:

$$Na_2O_2 + 2HCl = 2NaCl + H_2O_2.$$

It is consequently used as a bleaching agent for wool, silk, yarn, and various fibres, also in refining oil and fats, and in the straw-hat and other industries. Exposed to the air in contact with combustible materials it constitutes a dangerous material, owing to the heat developed by its decomposition with moisture.

The Castner-Kellner Alkali Co., Ltd., of Liverpool, issue a pamphlet respecting this compound and its uses, and details of its manufacture are given (*Ind. Chem.*, 1926, ii., 441).

Sodium Carbonate (Soda Ash) (Na_2CO_3)—Sodium carbonate is extensively used in glass manufacture, and is the basis of "washing-soda" (soda crystals ($Na_2CO_3 10H_2O$)), which is so largely employed for cleansing purposes. In its several commercial forms it is obtained from common salt by a number of chemical processes.

When common salt (NaCl) is subjected to the action of strong sulphuric acid at a temperature of about 49° C., the interaction produces sodium sulphate (salt-cake) and hydrochloric acid gas, which latter substance can be subsequently condensed and dissolved in water. By the old superseded Leblanc process, crude sodium carbonate is made by furnacing sodium sulphate (produced as above described) with chalk or limestone or lime and small coal, when a number of chemical changes take place of which a general view is indicated by the equation

$$Na_2SO_4 + 2C + CaCO_3 = CaS + 2CO_2 + Na_2CO_3,$$

calcium sulphide being formed together with the sodium carbonate,

SODIUM (*Continued*)—

which can be afterwards dissolved out of the fluxed mass with water and purified. This process is still declining, only 83,094 tons of salt having been decomposed by it in 1929.

The recovery of sulphur from the calcium sulphide of alkali waste by the Chance process is described under the heading of Sulphur.

Soda crystals ($Na_2CO_3,10H_2O$) effloresce or give up water when exposed to the air, the crystals falling to powder having the composition $Na_2CO_3H_2O$. Another form can be obtained in rhombic crystals by crystallization from hot solutions, with the composition $Na_2CO_3,7H_2O$—a soluble salt, 100 parts water dissolving 59 parts at 32·5° C.

In addition to the pure anhydrous state, sodium carbonate is marketed in crystal form, and also as so-called "soda-ash" of 58 per cent. strength.

Apart from the uses of sodium carbonate already noted, it is largely employed in ceramics and paper-making, the manufacture of soaps, wool-scouring, metallurgy, as a flux, and in the leather trade.

Sodium Bicarbonate—Sodium-hydrogen carbonate or so-called *bicarbonate* ($NaHCO_3$) is obtained commercially by the ammonia-soda process referred to below, but can be made by the action of carbon dioxide upon the ordinary carbonate:

$$Na_2CO_3,10H_2O + CO_2 = 2NaHCO_3 + 9H_2O.$$

Sodium carbonate and bicarbonate deposits occur naturally in British Columbia, where they are used in soap-making. There is also a so-called sesquicarbonate of sodium which occurs in Egypt and elsewhere as a natural deposit, having the composition expressed by the formula $Na_2CO_3,2NaHCO_3,2H_2O$ (see Sodium, p. 824).

In the ammonia-soda process, sodium chloride and ammonia-hydrogen carbonate (ammonium bicarbonate) are made to interact in such a way as to result in the formation of ammonium chloride and hydrogen sodium carbonate ($(NH_4)HCO_3 + NaCl = NaHCO_3 + NH_4Cl.$). A brine solution is saturated with ammonia gas, and the liquid is then charged with carbon dioxide gas; the sodium bicarbonate thus produced, being but slightly soluble in cold water, separates out, and can be converted into the normal carbonate by calcination. The ammonium chloride, which is more soluble, remains in solution, and the ammonia is afterwards recovered from it by the action of lime, giving calcium chloride as a by-product ($2NH_4Cl + CaH_2O_2 = CaCl_2 + 2NH_4HO$). The calcium chloride by treatment with zinc oxide and carbon dioxide under pressure produces zinc chloride and calcium carbonate, which can be used again to produce carbon dioxide, and the zinc chloride can be electrolyzed, producing electrolytic zinc and chlorine (L. Mond (*J.S.C.I.*, 1885, p. 527) and Jusch Kevitsch (with others) (*B.C.A.*, 1932, B, 179).)

Sodium bicarbonate is largely used in compounding effervescent salts, artificial mineral waters, baking-powders, and in the textile, tanning, paper, ceramic, and other industries.

Sodium sesquicarbonate ($Na_2CO_3,2HNaCO_3,H_2O$) is produced by heating a solution of the bicarbonate, whereby a portion of carbon

SODIUM (*Continued*)—

dioxide is evolved, and the salt crystallizes out upon cooling. A natural salt of this character occurs in certain lakes in South America and Africa, and is known as Urao. (See Trona.)

Sodium Percarbonate ($Na_2C_2O_6$)—A compound described under this name is said to be more suitable than sodium dioxide (NaO_2) as a bleaching agent for fabrics. (See Bleaching.)

Sodium Sulphate (Na_2SO_4) (known commercially as Glauber's salts and "salt-cake") is found naturally as the mineral *thenardite,* whilst *glauberite,* of which many deposits are found in Utah and Southern California, is a double sulphate of sodium and calcium. There are also a number of deposits of sodium sulphate in Canadian lakes, one of which (Muskiki Lake) is worked near Dana and another at Frederick Lake, being used for conversion into acid sodium sulphate for the separation of copper and nickel.

Apart from its incidental production in various processes, it is obtained from Stassfurt salts by interaction between magnesium sulphate and sodium chloride: $2NaCl + MgSO_4 = Na_2SO_4 + MgCl_2$. It is a highly soluble substance of efflorescent character which crystallizes with 7 and 10 molecules of water ($Na_2SO_4,7H_2O$ and $Na_2SO_4,10H_2O$) respectively, which melt in their own water of crystallization when heated to 33° C. It is known to exist in several polymorphic modifications. By exposure to the air, it gradually loses all its water, and is then known as "desiccated Glauber's salts." It has medicinal value as a purgative, and finds many uses, particularly in glass-making, nickel refining, and dyeing, while it is also of importance as the starting material for the manufacture of sodium sulphide.

A spray-dried variety weighing 30 lbs. to the cubic foot is now being produced in Canada from the natural deposits, 44 lbs. of which have the same strength as 100 lbs. of the crystallized salt, the clarified brine being sprayed down from towers, encountering hot gases from oil burners, and being deposited at their base as a fine powder.

By electrolysis under suitable conditions, a solution of the sulphate yields caustic soda at the cathode and sulphuric acid and oxygen at the anode, and given plentiful supplies of the salt and other favourable conditions, the process might prove of industrial value. (See Chlorine (Zahn Process, p. 185).)

A continuous mechanical furnace for its production by action of sulphuric acid on salt is described (*Ind. Chem.*, 1931, vii., 461); its industrial areas are summarized by L. H. Cole (*C.T.J.*, 1927, **80,** 80); its purification from iron (*C.T.J.*, 1932, **90,** 6); and a review of the world's supplies is given by H. O. Moraw (*C.T.J.*, 1930, **87,** 157 and 202).

Sodium Hydrogen Sulphate ($NaHSO_4$), known also as "bisulphate," acid sodium sulphate, and "nitre-cake," was produced on an immense scale during the Great War as a by-product in the manufacture of nitric acid which is generally not pushed beyond the first stage, as represented by the equation $NaNO_3 + H_2SO_4 = NaHSO_4 + HNO_3$ (see p. 619), and it became a matter of considerable importance to devise

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means of utilizing this residual substance containing the equivalent of a mixture of 30 per cent. sulphuric acid and 70 per cent. of sodium sulphate. In one of these methods, ammonia gas is passed into a heated solution of the nitre-cake containing a proportion of sulphuric acid, and after saturation, the bulk of the sodium sulphate (Na_2SO_4) thus produced is crystallized out, leaving ammonium sulphate in the mother-liquor, from which it can be obtained by crystallization or evaporation to dryness. In other words, the acid sodium sulphate (sodium-hydrogen sulphate) is thus converted into the normal sulphate, ammonium sulphate being simultaneously produced:

$$2NaHSO_4 + 2NH_3 = Na_2SO_4 + (NH_4)_2SO_4.$$

In another method *gafsa* phosphate is dissolved in a solution of nitre-cake, 100 parts of the phosphate (59 per cent. strength) requiring about 184 parts of the nitre-cake to furnish the required amount of SO_3; 44·63 parts of water being used and subsequently increased by a further 10 per cent. The product thus obtained is used as a fertilizer.

H. H. Gray suggested the utilization of nitre-cake, and an improvement in the manufacture of nitric acid, based upon the fact that gaseous or concentrated liquid hydrochloric acid causes the precipitation of sodium chloride from a solution of nitre-cake—

$$NaHSO_4 + HCl \longrightarrow H_2SO_4 + NaCl;$$

the hydrochloric acid, being relatively insoluble in sulphuric acid of more than 70 per cent. strength, allows the reversible reaction—

$$NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$$

to proceed, so that a hope was held out that a cyclic process—

$$\begin{aligned}&(1)\ NaCl + NaHSO_4 \longrightarrow Na_2SO_4 + HCl,\\ &(2)\ NaHSO_4 + HCl \longrightarrow NaCl + H_2SO_4,\end{aligned}$$

might be based upon these reactions. The two end products are sulphuric acid and sodium sulphate, and although some sodium sulphate may be contained in the acid product, it might be used in a nitric acid plant.

Nitre-cake can be utilized to generate fuming sulphuric acid by dry distillation, and was used during the war in grease recovery, bleaching and dyeing, metal pickling, hydrochloric acid manufacture, mineral water making, as a flux in decomposition of certain minerals, and otherwise to the total extent of 288,000 tons. Its production from natural sulphate as conducted in Ontario for use in the "Oxford" process for separation of the mixed sulphides of copper and nickel in the matte from the copper cliff mines is described (*C.T.J.*, 1930, **87,** 583).

Sodium-Aluminium Sulphate (Soda Alum)—See Alums, p. 40.

Sodium Bromide (NaBr) and the **Iodide** (NaI), both of which are used in photography and medicine, are readily soluble in water and

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are white crystalline salts produced by processes like those used for preparing the corresponding potassium compounds. (See *C.T.J.*, 1924, **75**, 297 and 704.)

The iodide is also employed as a solvent of iodine, and to some extent in the wet extraction of silver.

Sodium Fluoride (NaF) is a white crystalline salt soluble in 25 parts of water, and the solution, which attacks glass, is used in etching, also as an insecticide, and for other applications. It is prepared by neutralizing hydrofluoric acid with sodium carbonate, and a Russian process is described in *C.T.J.*, 1931, **89**, 245.

Sodium Nitrate ($NaNO_3$), m.p. 316° C., is easily obtained in a state of purity by recrystallization from its crude source (Chile nitre). The brine from Matsap Pan, in the Hague district of South Africa, contains, it is stated, 4½ tons of nitrates (chiefly sodium nitrate) in every 20,000 gallons of brine. It is a somewhat deliquescent, incombustible, and very soluble salt, 100 parts water dissolving nearly 69 parts at 0° C. and 102 parts at 40° C. Apart from its use in connection with the production of nitric acid, and the curing of meat (to preserve the colour), it is of value in mining, manufacture of military detonating explosives, firework-making, as a fertilizing agent, a flux in the glass industry, and for use in the production of potassium nitrate. (See Caliche, Potassium (Nitrate), and a reference to Sodium Nitrate (p. 825).)

Sodium Persulphate (Perdisulphate) ($Na_2S_2O_8$) is prepared like the corresponding potassium salt—viz., by electrolysing a solution of sodium-hydrogen sulphate in a divided cell—and finds use in the preparation of strong hydrogen dioxide. It is stated to be non-explosive. (See Hydrogen Dioxide, p. 463.)

Sodium Sulphites—of which there are a number—are referred to elsewhere. (See Sulphur Compounds, p. 876.) They are used commercially on account of their value in the brewing industry and as bleaching agents. The bisulphite powder ($NaHSO_3$) used in the brewing trade has a value in terms of SO_2 (sulphur dioxide—upon the basis of which it is sold) of from 60 to 67 per cent., and it is also prepared in liquid form of 70° Tw. strength yielding about 25 per cent. SO_2 in use. The composition and evaluation of this compound are described by J. B. P. Harrison and M. F. Carroll (*J.S.C.I.* 1925, **44**, 127 T).

Sodium Hydrosulphite ($Na_2S_2O_4 2H_2O$) is a yellowish-white crystalline substance, soluble in water, used as a bleaching and reducing agent. It is made by dissolving zinc in sodium bisulphite and precipitation with milk of lime, leaving the sodium hydrosulphite in solution. The water of crystallization can be removed from the salt by hot alcohol. A new method of production by the reduction of sulphur dioxide with sodium amalgam is referred to by Rabinowitsch and Fokin (*Nature*, 1930, p. 1908). (See Hydrosulphites and "Hydros.")

Sodium Thiosulphate (Hyposulphite $Na_2S_2O_3$)—See Sulphur Compounds, p. 876.

SODIUM (*Continued*)—

Sodium Phosphates are commercially prepared by the action of phosphoric acid upon sodium carbonate or caustic soda. The chief one is the common or di-sodium-hydrogen orthophosphate prepared by interaction in solution between sodium carbonate and phosphoric acid. It is an efflorescent, crystalline salt of composition $Na_2HPO_4,12H_2O$, which becomes anhydrous upon heating, and is used in various trades, including the compounding of baking-powder.

Other crystalline phosphates are the normal sodium orthophosphate, $Na_3PO_4.12H_2O$ (tribasic), used in medicine, and sodium di-hydrogen phosphate, $NaH_2PO_4H_2O$ (monobasic), which is also used in making baking-powders. All these phosphates are soluble in water.

Tribasic, or so-called tri-sodium phosphate (Na_3PO_4), is manufactured by churning a boiling solution of soda-ash (which can be prepared from "Trona") with a calculated amount of strong phosphoric acid, and subsequently treating the solution of the Na_2HPO_4 thus produced with a strong solution of caustic soda, the several reactions being represented as: $Na_2CO_3 + H_3PO_4 = Na_2HPO_4 + CO_2 + H_2O$, and $Na_2HPO_4 + NaHO = Na_3PO_4 + H_2O$, the tribasic salt being crystallized out from the final product as $Na_3PO_4,12H_2O$, which loses $11H_2O$ at 100° C. The process as conducted at Los Angeles, California, is described in the *C.T.J.*, 1929, **85**, 302; see also *C.T.J.*, 1931, **88**, 5, and F. D. Snell (*Ind. Eng. Chem.*, May, 1931). It has been found effective for the treatment of high-pressure boiler-feed water up to pressures of 1,000 lbs. when used together with a small proportion of caustic soda, resulting in the deposition of calcium as phosphate and magnesium as phosphate or hydroxide (H. E. Jones). (See also *Ind. Chem.*, 1931, vii., 517, and P. Koeppel (*B.C.A.*, 1931, B, 745).) A 15 per cent. solution at 70° C. is useful as a detergent for cleaning burettes and volumetric glassware and otherwise as a general emulsifying and cleansing agent.

Sodium pyrophosphate, an opaque, crystalline, white salt, has the composition $Na_4P_2O_7.6H_2O$, derived from pyrophosphoric acid ($H_2P_2O_7$), and there are a number of so-called metaphosphates obtained from metaphosphoric acid (HPO_3) (or so-called glacial phosphoric acid), including the sodium salt $NaPO_3$; the dimetaphosphate is $Na_2P_2O_6$, and the trimetaphosphate $Na_3P_3O_9$.

The so-called *microcosmic salt* ($NaH(NH_4)PO_4,4H_2O$) is a crystalline salt corresponding to NaH_2PO_4, in which an atom of hydrogen is replaced by ammonium; obtained by mixing solutions of ordinary sodium phosphate and ammonium chloride.

Sodium Phosphites—Of these, there are two, which are represented by the formulæ Na_2HPO_3 and NaH_2PO_3 obtained from phosphorous acid (H_3PO_3), and the hypophosphite $NaH_2PO_2.H_2O$ (used in medicine).

Sodium Nitrite ($NaNO_2$) is a stable crystalline salt of m.p. 213° C., resulting from reduction of the nitrate by heating with metallic lead above its fusion-point (450° to 500° C.), but commercially made by an electrolytic process. Its manufacture by the arc process is described

SODIUM (*Continued*)—

by H. K. Benson (*C.T.J.*, 1925, **77,** 358). It is used in the dye industry, making nitric oxide, the economical curing of pork, tongues, and beef, and as a substitute for potassium nitrite.

Sodium Hyponitrite—Preparation and properties. (See Partington and Shah, *J.C.S.*, 1931, p. 2071.)

Sodium Sulphide (Na_2S) is a reddish-yellow compound soluble in water, prepared for commercial purposes in crystalline form containing 30 to 33 per cent., and in a fused form of 60 to 65 per cent. strength. It is commonly made from the sulphate by heating with coal slack or coke at a low temperature in a rotary fuel-fired furnace. This gives a low yield and slow production, whilst a high temperature gives rapid production and corrosive destruction of the furnace. As thus made, when crystallized from aqueous solution, it contains 9 molecules of water and 32·5 per cent. Na_2S, and upon further evaporation and continued heating up to 160° C. a final product is obtained containing 60 to 65 per cent. Na_2S which is cast into slabs. It can also be made by the action of hydrogen sulphide upon caustic soda, and is a by-product in making barium carbonate by treatment of barium sulphide with sodium carbonate. It is used severally for denitrating artificial silk, for decomposing silver iodide (as a substitute for the "Claudét" process), for separating gold and silver from tower-acid liquors, in the manufacture of sulphur dyes and paper-making industry, and as a depilatory in tanning, etc.

An improved electric-furnace process yields a grade of 90 to 95 per cent. of practically anhydrous character, and colourless crystals can, it is stated, be produced by a method described in *C.T.J.*, 1932, **90,** 242. Sodium sulphide will flux all known refractories, and the electrical process obviates their employment (*C.T.J.*, 1925, **77,** 93; and *Ibid.*, 1927, **81,** 470, 494, 515, and 544). There are other sulphides corresponding to the potassium sulphides, and all can be used as depilatory agents and in the manufacture of black sulphur dyes. A critical investigation of the formation and properties of sodium polysulphides is the subject of a paper by Pearson and Robinson (*J.C.S.*, 1930, p. 1473).

Sodium Hydrosulphide—See Hydrosulphides.

Sodium Oxalates—The white normal salt ($Na_2C_2O_4$) and the acid salt ($NaHC_2O_4H_2O$) are both crystalline and soluble in water, and are used in the leather, tanning, and textile industries. The normal salt occurs in *varech*, also in a number of other plants. (See Oxalic Acid.)

Sodium Manganate and Permanganate—See Manganese Compounds, p. 561.

Sodium Tannate—A compound of tannic acid (gallotannic acid) with soda; used in dyeing and for removing incrustations in boilers.

Sodium Borates—See Shorgi and Amelotti (*B.C.A.*, 1930, A, 1122), and Boron Compounds.

Sodium Perborate ($NaBO_34H_2O$) is a colourless, crystalline salt pre-

SODIUM (*Continued*)—

pared by mixing a 3 per cent. solution of hydrogen dioxide with a saturated solution of borax in alkaline solution at a low temperature, when it is deposited in crystalline form on standing. It is produced electrolytically from a solution of sodium carbonate and borax. Another patented method is based upon the interaction of sodium peroxide and sodium metaborate, the first-named salt being dissolved in water and the cold solution saturated with carbon dioxide, then mixed with a saturated solution of the metaborate. The sodium perborate which crystallizes out is separated by filtration and dried. It is a dangerous substance, being liable to decompose with violence, although stated to be stable in air kept free from carbon dioxide. It contains 10·4 per cent. of oxygen, and is used in compounding preparations for washing and bleaching textile fabrics and as a general oxidizing agent. Proprietary brands of this substance are sold as "Clarax" and "Ozonite." (See V. Stepanov (*B.C.A.*, 1926, B, 786); *C.T.J.*, 1926, **79,** 443; 1927, **81,** 559; and 1932, **90,** 127.)

Sodium Acetate ($NaC_2H_3O_2,3H_2O$) is a colourless, crystalline, efflorescent body soluble in water, and has commercial applications, including preservation of meat and preparation of mordants.

Sodium Amalgam can be prepared by heating mercury to 200° C., and adding sodium in small pieces slowly, or by melting sodium under a layer of toluene and adding mercury slowly to the melted sodium. (See Read and Lucarini, *B.C.A.*, 1925, **44,** B, 507.) Various grades may be made containing sodium from 2 to 10 per cent., and are useful as reducing agents, also for the preparation of hydrogen.

Sodium Arsenates are isomorphous with the phosphates and include the following well-known salts—viz., trisodium ortho-arsenate (or normal arsenate, $Na_3AsO_4 12H_2O$), a salt which is commercially known as arseniate, marketed of 45 per cent. strength, and used as an antiseptic, also in dyeing, in medicine, and as a fungicide; di-sodium hydrogen ortho-arsenate, Na_2H,AsO_4, largely used in calico-printing; sodium di-hydrogen ortho-arsenate, $NaH_2,AsSO_4$; sodium pyro-arsenate, $Na_4As_2O_7$; and sodium meta-arsenate, $NaAsO_3$.

Sodium Arsenite (Na_2HAsO_3) is a white compound, soluble in water; used in making arsenical soap for taxidermists, and in dyeing.

Sodium Chlorite ($NaClO_2,3H_2O$), prepared from barium chlorite and sodium sulphate, forms lustrous laminæ, and in the anhydrous form explodes on percussion.

Sodium Sulphocyanide (NaCNS)—Made by boiling sulphur in sodium cyanide solution; used in bismuth refining.

Sodium Chlorate ($NaClO_3$) and **Perchlorate** ($NaClO_4$) are white crystalline salts, soluble in water, prepared much in the same way as the more important potassium compounds and used for the same purposes. The chlorate finds use in calico-printing processes and for destroying harmful weeds on farms, and, being more soluble than the potassium salt, is preferred for making aniline black.

SODIUM (*Continued*)—

Sodium Chromate and **Sodium Dichromate**—See Yushkevich and Shokin (*B.C.A.*, 1927, B, 936), and Chromium Compounds (p. 191).

Sodium Silicofluoride (Fluosilicate, Na_2SiF_6) is a white substance, only slightly soluble in water; used in ceramics and as an insecticide.

Sodium Tungstate—See Tungsten.

Sodium Aluminate ($Na_2Al_2O_4$) is a white compound soluble in water, resulting from the fusion of bauxite or precipitated aluminium hydroxide with sodium carbonate; used as a mordant and water softener for boiler water. (See Beal and Stevens on use of this compound in modern water treatment (*J.S.C.I.*, 1931, **50**, 307 T).)

Sodium Hydride (NaH)—Prepared in white needle-like form by interaction between sodium vapour and hydrogen at 400° to 450° C. (See Hagen and Sieverts, *B.C.A.*, 1930, A, 307.)

Sodium Hypochlorite (NaClO)—See Chlorine Compounds, p. 186.

Sodium Nitroprusside ($Na_2Fe(CN)_5NO.2H_2O$), a red crystalline salt soluble in water, used as a reagent and for some technical purposes.

Sodium Salicylate ($NaC_7H_5O_3$), a white crystalline salt soluble in water and used in medicine; prepared from sodium phenoxide and carbon dioxide by heating in an autoclave.

Sodium Benzoate ($NaC_7H_5O_2$) is a crystalline salt soluble in water; used as a food preservative, and in medicine.

Sodium Naphthionate ($NaC_{10}H_6(NH_2)SO_3.4H_2O$), a colourless crystalline intermediate soluble in water.

Sodium Citrate ($2Na_3,C_6H_5O_7,11H_2O$)—A white, soluble crystalline salt; used in medicine and for compounding non-alcoholic drinks.

Sodium Tartrate ($Na_2C_4H_4O_6.2H_2O$) is a white crystalline salt soluble in water; used in medicine.

Sodium Cyanide is produced quantitatively by the passage of carbon monoxide and ammonia gas over finely divided soda at from 600° to 650° C. It is also made by passing ammonia through melted sodium mixed with charcoal. It is a very poisonous compound and chiefly used for the extraction of gold and silver from ores. (See reproduced article (*Ind. Chem.*, 1930, vi., 375); also Cyanogen, p. 260.)

Sodium Formate ($NaCHO_2$)—A soluble salt which can be prepared in a crystalline anhydrous state and also in association with water ($NaCHO_2,H_2O$); used in making formic and oxalic acids.

Sodium Ethoxide (NaC_2H_5O)—Produced by the action of metallic sodium on absolute alcohol and used as a synthetic agent.

Sodium (Prussiates) **Ferricyanide** and **Ferrocyanide** are soluble salts resembling the corresponding potassium salts, and are used industrially for the same applications; the ferrocyanide being also used in the smelting of ashes and residues of non-ferrous metals. (See p. 730.)

Sodium Glycerophosphate ($Na_2C_3H_7PO_6,H_2O$)—A yellow viscid liquid, soluble in water and alcohol; used in medicine. It is also known in crystalline form as prepared by heating glycerol with monosodium

SODIUM (*Continued*)—

phosphate and splitting off a molecule of glycerol from the diglycerol phosphate by means of caustic soda.

Sodium Phenate (or **Carbolate**) (NaC_6H_4OH) is a white, deliquescent, crystalline salt, prepared from phenol and caustic soda by mixing and heating in an autoclave (by which means the compound is desiccated); it is soluble in water and alcohol and used in the manufacture of salicylic acid and as an antiseptic, etc.

Sodium Silicate (**Soluble Glass,** or **Water-Glass**) is made by calcining either pure diatomaceous earth, quartz, or finely powdered flint or sand with caustic soda or sodium carbonate and (sometimes) powdered coal or coke, followed by extraction with water. Prepared in this way it is probably an indefinite mixture, the fused "lump silicate" varying in composition, being alkaline or neutral according to the composition of the charge. Silicon dioxide fused with sodium carbonate gives the soluble silicate Na_4SiO_4.

The following mixtures have been recommended for making lump water-glass in reverberatory furnaces—(*a*) 100 kilograms sand, 60 kilograms Na_2SO_4, 30 kilograms soda carbonate, 3 kilograms coke; (*b*) 150 kilograms sand, 80 kilograms Na_2SO_4, 20 kilograms soda carbonate, 3 kilograms coke; (*c*) 100 kilograms sand, 68 kilograms Na_2SO_4, 32 kilograms soda carbonate, 3 kilograms coke; (*d*) 100 kilograms sand, 50 kilograms Na_2SO_4, 16 kilograms soda carbonate, 3 kilograms coke—yielding waterglasses practically neutral, soluble in water with a very slight residue, giving easily filterable solutions, bluish-green to white in colour, which can be decolourized with charcoal if required.

It is known both in the anhydrous form (Na_2SiO_3), and as Na_2SiO_3, $9H_2O$; is soluble in water (the limits for complete solubility being about 21·5 to 42·1 per cent. SiO_2 and 5·25 to 26·95 per cent. Na_2O), and is used in dyeing, calico-printing, grease-proofing paper, for the reclamation of crank case oils, the facing or lining of corrugated paper, hardening concrete, iron enamelling, in the built-up paper-board industry, fire-proofing fabrics, making adhesives, paints, distempers, artificial stone, cements, soaps, etc.

It is marketed both as glass and in liquid form of 140° Tw. Some 85 per cent. of the world output of silicate is stated to be used in the soap and corrugated box industries, and when employed in abrasive wheels the addition of about 4 per cent. of potassium permanganate is recommended.

In solution (as so-called water-glass) it is largely used as a cleansing agent and for preserving eggs, the shells being made air-tight by dipping therein and drying, thus preventing the access of air-borne germs. It is also used for the preservation of stone-facings, the silica entering into combination with calcium of the limestone (of which so many buildings are constructed), thus forming on their surfaces a thin layer or coating of more or less insoluble calcium silicate, and preventing to some extent their further corrosion by carbon dioxide and moisture.

It has similarly been recommended, as a binding agent, for the

SODIUM (*Continued*)—

surface treatment of concrete roads and hardening concrete constructions owing to its formation of calcium silicate with the hydrated lime set free following the setting of cement, thus producing a non-porous hard coating and reducing the cost of upkeep. S. Mantel (*B.C.A.*, 1930, B, 420) states that the silication of limestone does not depend upon the formation of calcium silicate, but upon the separation of silica in the pores of the limestone as a result of hydrolytic action. Similarly it can be used for making dustless concrete floors. The metasilicate ($Na_2SiO_3,5H_2O$) has been advocated as a laundry detergent. (See C. L. Baker (*Ind. Eng. Chem.*, September, 1931); J. G. Vail on *Soluble Silicates in Industry* (Chem. Catalog. Co., Inc., N.Y.); *C.T.J.*, 1928, **83**, 202; and Concrete, p. 232.)

Sodium Stannate—See Tin Compounds.

Sodium Stannite—See Tin Compounds.

Sodium Vanadate ($Na_3VO_4.16H_2O$) is a white crystalline salt soluble in water, used in making aniline black and ink.

"SOFNOL"—A specially prepared calcium hydroxide for the softening of waters. Other "Sofnol" mixtures for different qualities of water are the "sofnol lime-soda mixture" and the caustic soda and soda-ash mixture known as the "sofnol marine mixture." As to the last named, the caustic soda is used to remove the magnesium salts and the carbon dioxide. "Sofnol soda-lime G" is an activated grade containing a fractional quantity of manganic acid, and is reported to have a much greater absorptive capacity than ordinary soda-lime for carbon dioxide. "Sofnolite" is a modified soda-lime prepared for analytical purposes. (See Filters, Volumetric Analyses, and Water Softening.)

SOILS—The outer crust of the earth covering the geological foundations of the land, consisting mainly of various mineral matters resulting from weathering—that is, the action of air, water, and other agencies upon rocks—mixed with organic (humous) substances derived from the decay of vegetable growths and animal matter. It has been conjectured that beneath the earth's surface for the depth of some 18 miles there is a mass of rocky siliceous compounds named *sial,* and beneath that again, a material of greater density named *sinia,* while the central core (the composition of which is a matter of much speculation) consists of an alloy of iron and nickel at a depth of some 2,450 kilometres. Beneath the sea, however, there is no *sial,* but the *sinia* starts immediately.

The chemical constitution of soils (from which plants obtain their mineral food) varies according to the nature of the rocks from which they have resulted and the processes which have taken place and are in course of action (soil genetics), and they are roughly described as of sand, chalk, clay, or loam, etc., according to the prevailing features. It has been suggested that the soil possesses some of the attributes of colloids, with respect to its powers of absorption and retention of water, and the soil moisture is certainly of great importance, inasmuch as it constitutes the nutrient solution for growing vegetation. The plant

SOILS (*Continued*)—

residual products present in soil furnish the micro-organisms which abound in them with food, the two more important ones being cellulose and proteins, which give rise respectively to humus and ammonia. The humus exercises important physical effects in the soil, and it is from the ammonia, which becomes bacterially oxidized to form nitrates, that growing crops obtain their nitrogen food, the two groups of organisms which effect this fixation being the *Azotobacter* and *B. amylobacter.* (See P. G. Krishna, *J. Agric. Sci.*, 1928, **18,** 432.) A sporing organism which easily decomposes cellulose in contact with the air is named *Spirochæta cytophaga,* and gives a simple nitrogen compound such as a nitrate or ammonia; it produces, among other things, a pigment like carotin. During the growth of clover, lucerne, trifolium, vetches, peas, beans, etc., fixation of nitrogen proceeds vigorously.

The acidity of soils is due to free alumino-silicic acid and humic acid, which, in the presence of air, by combination with the fertilizer base, yield free acidity, while "exchange" acidity is produced when soil is treated with a neutral salt, such as a potassium or nitrogenous fertilizer, through the exchange of a base of soil silicates with that of the fertilizer used. If these silicates contain much iron or aluminium, salts are produced which are acid and toxic to plants. The "B.D.H. soil-testing outfit" enables anyone to determine the "reaction" of soil easily and quickly.

Acid soils are infertile to most crops except potatoes, but the acidity can be remedied by liming, which renders potassium and phosphoric fertilizers more available, accelerates the conversion of nitrogenous fertilizers into ammonia, and favours the action of nitrifying bacteria, which develop more abundantly in a slightly alkaline soil. Liming is carried out by the use of lime, or chalk, or marl, etc.

Certain bacteria and fungi bring about the decomposition of protein, and active bacterial activity occurs, it is stated, to a depth of from 50 to 60 cm. below the soil surface. Two soil organisms which flourish particularly in soil dressed with farmyard manure are *Ps. fluorescens* and *Ps. caudatus.*

For the destruction of harmful bacteria, recourse is often had to the use of naphthalene or carbon disulphide, both of which substances are also useful for the destruction of many insect pests.

The changes effected by the micro-organisms and the protozoa (of which there are very great varieties) and other organic life found in various soils cannot be dealt with in a work of this character, but some other details are given under the headings of Vegetation and Nitrification.

Research appears to have shown that there is some factor in the nature of the other living organisms (protozoa) larger than bacteria which prey on them, and prevents them multiplying in sufficient amount to assist the growth of plants to their full possible effect. It has also been shown that partial sterilization with steam or formaldehyde materially assists in obtaining more than average crops of certain plants, and it is stated that potato wart can be entirely eliminated by the use of steam. See Russell and Buddin on "Antiseptics and the Growth of Crops in Soil"

SOILS (*Continued*)—

(*J.S.C.I.*, 1913, p. 1136); H. J. Page on "Science of the Soil" (*Chem. and Ind.*, 1927, **46**, 161); "Studies in Soil Genetics," by Jones and Willcox (*J.S.C.I.*, 1929, **48**, 304 T); "Microflora of Forest Soils," by R. Bokor (*B.C.A.*, 1930, B, 160); Thomas and Elliott on "*p*H Values of Soils" (*J.S.C.I.*, 1931, **50**, 303 T); *An Introduction to the Scientific Study of the Soil*, by N. M. Comber (E. Arnold and Co.); *Soils and Manures*, by J. A. Murray (Constable and Co.); *Soil Conditions and Plant Growth* (6th edit.), by E. J. Russell (Longmans); *Soil, the Physical Properties of the*, by B. A. Keen (Longmans); *The Soil and the Microbe*, by Waksman and Starkey (Chapman and Hall); the Rothamsted Reports of the Lawes Agricultural Trust at Harpenden, obtainable from the secretary; *Principles of Plant Biochemistry*, by M. W. Onslow (Part I.) (Cambridge Univ. Press); also Humus, Pachimeter, and Plant Colouring Matters.

SOJA-BEAN OIL—See Soya-Bean Oil.

SOLANINE (**Solanum** species) ($C_{54}H_{96}O_{18}N_2.H_2O$—a later formula is given as $C_{44}H_{71}O_{15}N$ by Zemplén and Gerecs (*B.C.A.*, 1929, A, 51))—A poisonous glucoside constituent of potatoes contained to the extent of from 0·02 to 0·1 part per thousand, and present in the young shoots up to 50 parts per thousand; m.p. 214°; soluble in 85 per cent. alcohol: also contained in bittersweet (*Solanum dulcamara*). (See H. Lowe, *Analyst*, 1929, **54**, 153.) The percentage contained in potatoes varies: in one reported case the amount was 0·0495 per cent., of which 0·0177 was in the peel, and in another case 0·079 per cent. was found, of which 0·0235 occurred in the peel. Three normal varieties of different kinds were found to contain respectively 2·0, 2·1, and 7·5 mgrms. of solanine in 100 grms. of potatoes, and in extreme cases quantities varying from 26 to upward of 58 mgrms. per 100 grms. of potatoes have been found. It is reported that the amount of solanine in potatoes is largely increased by their exposure to light.

SOLAR AND STELLAR CHEMISTRY—See Light, p. 538.

SOLDERS—See Alloys.

"SOLDIS"—A proprietary low-priced fluid disinfectant and wooden fence preservative of phenolic and cresylic character, miscible with water.

"SOLEDON"—The designation of a series of soluble vat dyes.

SOLIDS—Solid bodies can interact as evidenced by the blackening action of sulphur placed upon silver articles, and as further illustrated in the article on diffusion. In connection with this part of the subject, J. W. Jenkin has shown that at 1,000° C. copper diffuses into wires of single crystals of tungsten, even at a temperature very near to the melting-point of the more fusible metal.

The union of solid masses under pressure without melting is illustrated by the manufacture of tungsten wire and rods from the powdered metal.

Again, it is known that pure iron freed from previously encased gases

SOLIDS (*Continued*)—

is almost as soft as copper, and gold containing 0·01 per cent. bismuth becomes excessively brittle.

Doubtless the connection between chemical properties and crystalline structure, although indeterminate, is very intimate.

Certain specimens of brass will disintegrate into loose grains like sand very rapidly after immersion in a solution of mercurous nitrate, whereas nitric acid attacks the same specimens uniformly as if the condition of intercrystalline brittleness were totally absent.

See J. S. Dunn on "The Diffusion of Zinc in the *a*-Series of Solid Solution in Copper" (*J.C.S.*, 1926, p. 2973); C. H. Desch on "The Chemistry of Solids" (*Chem. and Ind.*, 1925, **44,** 907 and 924); also Diffusion and Solution.)

"SOLIGENATES"—Certain driers understood to be compounded of lead, manganese, and cobalt salts of naphthenic acids derived from the oxidation of petroleum; soluble in vegetable oils, turpentine, benzol, etc.

"SOLIGNUM"—A coal-tar preparation used as a wood preservative and a protective agent against white ants and other insect pests.

SOLS—See Colloids.

SOLUBILITIES—See *A Dictionary of Chemical Solubilities* (*Inorganic*), by Corney and Hahn (Macmillan and Co., London), and Solution.

SOLUTE—See Solution.

SOLUTION AND SOLVENT ACTION—Salt placed in water gradually disappears; the salt is *dissolved* and constitutes the *solute,* whilst the *solvent* (water), which was previously tasteless, becomes saline in taste, and constitutes a *solution* of salt or a homogeneous mixture presenting a single phase. (See Colloid Chemistry.) Many other liquids have this power of dissolving solid substances, the products being homogeneous mixtures. There are cases known in which there are increased solubilities of substances in mixed solvents when the solute is only slightly soluble in only one of the solvents. Again, many liquids have the power of absorbing or dissolving certain gases; hydrochloric acid gas, ammonia, sulphur dioxide, and chlorine are all soluble in water, absorption in this sense being the same thing as solution or solubility. Further, many liquids, such as certain oils and hydrocarbons, are soluble in alcohol, ether, and some other liquids, and solution in this sense is identical with that of a solid substance dissolved in a liquid.

Gases also have the property of holding substances in solution; air, for example, will take up a given quantity of water according to the temperature, and the mixture may be regarded as one of water dissolved in air. (See Air (p. 14), Dew Point, and Hygrometers.)

Solutions of solids in solids are also known, solid solutions being defined as solid homogeneous complexes of several substances—presenting, that is, a single phase. Isomorphic mixtures are solid solutions. The proportions of the several substances may vary without affecting

SOLUTION AND SOLVENT ACTION (*Continued*)—

the homogeneity. Solid solutions may also result from occlusion of gases in charcoal and occur in mixed crystals. (See Dehlinger and Graf on "Transformation of Solid Metallic Phases" (*B.C.A.*, 1930, A, 1360); Alloys, Diffusion, and Solids.)

There is good reason for believing that in some cases when substances are dissolved in liquids, real chemical combination takes place (the liquids entering into reaction), as, for example, when sodium carbonate is dissolved in water; for if this solution be concentrated by evaporation to a sufficient extent, there is produced on cooling a mass of crystals of common washing soda in which the sodium carbonate is definitely combined with water ($Na_2CO_3,10H_2O$). The heat generated by admixture of strong sulphuric acid with water affords further evidence of chemical combination. In other words, the active constituents of solutions appear to form complexes with the solvent molecules. The view has been expressed by Walker that although such a hydrate as H_2SO_4,H_2O can be crystallized, it is no proof that it previously existed as such in solution, and this view is upheld by Lowry in his lecture referred to below. When a substance is dissolved in water there is generally a fall in temperature, and the amount of heat which disappears or is evolved when a definite amount of the substance is dissolved in a solvent varies according to the concentration, and is known as the "heat of solution"; that for 1 grm.-molecule of sodium chloride, for instance—viz., 58·5 grms. in 100 grm.-molecules of water (1,800 grms.)—being 1,200 calories.

There are certain conditions under which some solutions will solidify as a whole, and such solids were at one time defined as cryohydrates, but that term is now restricted to solidified mixtures of solute and solvent (water), which are of the same composition as the solution, the "eutectic" point on a graph being that where the curves of temperature representing the separation intersect. Any change of temperature disturbs the eutectic state of four phases—viz., solid solute, solid solvent, solution, and vapour—causing the disappearance of one of them. (See Eutectic.)

As a general rule, the solubility of a solid in a liquid increases with the temperature, and when a solution will not dissolve any more of the substance at any particular temperature it is said to be *saturated*. A solution is said to be *dilute* in character when it contains but little of its particular ingredient, and is described as strong or *concentrated* when the proportion of dissolved substance is great in quantity. Many solutions which are not already saturated can be strengthened or concentrated by evaporation of some of the solvent. For instance, a dilute solution of sodium nitrate in water may be concentrated by the application of heat (which causes the evaporation of some of the water) to such a stage of super-saturation that, when cooled, the excess of the salt will crystallize out on cooling. On the other hand, strong solutions can be weakened (*diluted*) by the addition of more solvent. (See Crystals and Solvents.)

With respect to electrolytic dissociation of electrolytes in solution into

SOLUTION AND SOLVENT ACTION (*Continued*)—
ions, the amount split up is the greater, the greater the dilution, although this is only true of weak electrolytes (Ostwald's Dilution Law).

"Normal" and "standardized" solutions are described under the heading of Volumetric Analyses.

See C. J. Brockman on "Dissociation in Solution" (*Chem. and Ind.*, 1925, **44,** 501); "A Method for Determining the Solubilities of Sparingly Soluble Substances," by S. Mitchell (*J.C.S.*, 1926, p. 1333); R. Wright on "Selective Solvent Action" (*J.C.S.*, 1926, p. 1203); T. M. Lowry on "Solutions" (*Chem. and Ind.*, 1928, **47,** 1233 and 1260); "An Apparatus for the Determination of Solubility," by A. N. Campbell (*J.C.S.*, 1930, p. 179); "Apparatus for comparing Rate of Solution of Solid Substances," by V. Cofman (*Chem. and Ind.*, 1931, **50,** 1057); work by A. Seidell and supplement to 2nd edit. (D. Van Nostrand Co., Inc., N.Y.); *Conductivity of Solutions,* by C. W. Davies Chapman and Hall, Ltd.); and *The Electrochemistry of Solutions*, by G. Glasstone (Methuen and Co., Ltd.).

SOLVENT NAPHTHA—See Benzol, Coal, Naphtha, and Petroleum.

SOLVENTS—In addition to water (the greatest general solvent), acetone, ethyl alcohol, normal and isopropyl alcohols, tertiary butyl alcohol ethylene glycol, cyclohexanol, methylcyclohexanol, diacetone alcohol, the acetates of various alcohols and many new esters, benzene, petrol, naphtha, carbon tetrachloride, carbon disulphide, turpentine, and other agents, and a number of colourless chlorinated organic solutions have in recent years come into extensive use in connection with fats, oils, paints, rubber, etc. Some of these (obtained by the action of chlorine on acetylene) are tabulated below, and the dichloro-ethylene and trichloro-ethylene are particularly favoured on account of their non-inflammable character, their chemical stability and resistance to hydrolysis, while their vapours do not form explosive mixtures with air, and do not attack the metallic parts of chemical plants. Trichloro-ethylene is relatively harmless, but the vapour of tetrachlorethane is highly poisonous.

	Dichloro-ethylene ("Dieline").	Trichloro-ethylene ("Trieline").	Tetrachloro-ethylene ("Eteline"). ("Perchlor-ethylene").	Tetrachloro-ethane ("Tetraline").	Pentachloro-ethane ("Pentaline").	Hexachloro-ethane (or Perchloro-ethane).
Formula ..	$C_2H_2Cl_2$	C_2HCl_3	C_2Cl_4	$C_2H_2Cl_4$	C_2HCl_5	C_2Cl_6
B.P. ..	52°	85°	119°	144°	159°	185°
Sp. gr. ..	1·278	1·471	1·628	1·62	1·685	2·0
Solvent for	Rubber, etc.	Paraffin, "vaseline," etc.	Cleaning purposes	Resins, varnishes, and cellulose acetate	Cellulose acetate and films	Used as insecticide

Ethylene dichloride ($C_2H_4Cl_2$) can be used without danger, presents a very low fire hazard, and its chemical stability and resistance to hydrolysis give it advantages as a solvent over carbon tetrachloride. (See Ethylene Dichloride.)

SOLVENTS (*Continued*)—

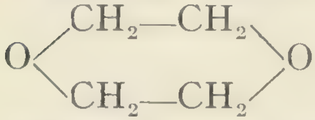
A range of solvents are described as "Ketols" (that is, compounds having a keto and alcoholic (OH) group, as, for example, CH_3COCH_2OH), but essentially complex mixtures of ketones, made by the fermentation of sawdust in presence of lime and dry distillation of the resulting calcium butyrate, etc.; fractionation of the distillate yields liquids of b.p.s ranging from 60° to 200° C., said to be good solvents of highly nitrated cellulose.

Some of these various solvents (many of which are bought on a volume rather than a weight basis) are miscible with water; others have a greater volatility than ethyl alcohol, and lower inflammability; they vary in their boiling-points and other characteristics, but while many of them serve for special applications, most of them are dearer than duty-free ethyl alcohol.

Several amylene dichlorides, described as pentanes, in which hydrogen atoms have been substituted by chlorine, are used as solvents, of wax, tar, oils, gums, resins, rubber, etc. Solvents are variously used for the purposes above mentioned, as also for dry cleaning garments and in the rubber, varnish, paint, lacquer, and solvent soap industries.

Dichloroethylether ($CH_2Cl.CH_2OCH_2.CH_2Cl$) is a solvent produced by a New York firm. It boils at 178° C., is insoluble in water but soluble in alcohol, ether, and benzene, and can be used for fats and "spotting" cellulose acetate fabrics; also as a general cleansing agent.

Another solvent is a derivative of ethylene named "Dioxan"



(diethylenedioxide), a colourless liquid of faint, pleasant odour, miscible with water and the usual organic solvents; m.p., 11° C.; b.p. 101·1° C.; density at 20° C., 1·0338; and ref. ind. (Abbé refractometer) 18° C., 1·4238. It is described as an excellent solvent for resins of the alcohol and oil soluble types, vegetable and mineral oils, greases, blown linseed and other oils, certain waxes (including beeswax and carnauba wax), and it can be employed in the manufacture of various types of lacquers, celluloid, varnishes, polishes, paints, etc., and other products dependent upon the employment of nitrocellulose, cellulose acetate, etc. (See Reid and Hofmann (*Ind. Eng. Chem.*, July, 1929, or *C.T.J.*, 1929, **85,** 64); "Solvent Clarification of Dry Cleaning Spirit" (*Ind. Chem.,* 1927, iii., 109); "Solvent Recovery by Activated Carbon" (*Ind. Chem.*, 1928, iv., 191); "Solvents from Natural Gas," by H. S. Garlick (*Ibid.,* 1928, iv., 363); "The Handling of Organic Solvents" (Industrial Safety), by R. Brightman (*Ind. Chem.,* 1930, vi., 209); "The Petroleum Industry as a Supply for Industrial Solvents," by J. A. Park (*Chem. and Ind.*, 1931, **50,** 620); "The Solvent Extraction of Vegetable Oils," by A. E. Williams (*Ind. Chem.*, 1931, vii., 161); "The British Solvents Industry" (*C.T.J.*, 1931, **88,** 479, and *Ind. Chem.*, 1931, vii., 109); "Solvent Recovery by the Bayer Active Carbon Process in the Manufacture of Cordite," by J. C. Liddle (*Chem. and Ind.*, 1932, **51,** 3); "Solvents from the Gas Industry," by C. R. Downs (*Chem. and Ind.*, 1932, **51,** 28 and 45);

SOLVENTS (*Continued*)—

Solvents, by T. H. Durrans (Chapman and Hall, Ltd.); Carbon, p. 140, and Silica (Silica Gel), p. 807.)

SOMBRERITE—An impure mineral calcium phosphate ($Ca_3(PO_4)_2$) found in Sombrero and other islands of the Antilles.

"SOMNAL"—See Chloral.

SOOT finds use as an effective mild soil fumigant, particularly when used fresh, and has some value as a fertilizer for cereals and grass by reason of its ammonium sulphate content. It has been estimated that no less than 3,000,000 tons of potential fuel are wasted into the air in the form of soot in this country. Its suggested utilization in place of coal and coke is referred to under Ores, p. 646. (See also *Analyst,* 1931, **56,** 811.)

SORBIC ACID ($C_6H_8O_2$)—Found in the unripe sorb apple (*Sorbus aucuparia*) and mountain-ash berries.

"SOREL CEMENT"—A strong binding, made by mixing calcined magnesia with concentrated solution of magnesium chloride, which sets to a hard mass of the composition $MgCl_2,5MgO,xH_2O$ (the value of x being about 17). It is extensively used in combination with various fillers, such as asbestos, cork-dust, wood flour and sawdust for interior finishing, such as stucco, flooring, and building materials. Its corrosive action on ironwork is stated to be obviated by the substitution of ferrous chloride in sufficient quantity for magnesium chloride in the making. This newer product is blue, but turns brown upon exposure to the air, and although possessing the advantage indicated, it is said to be not completely water-resistant. (See *B.C.A.*, 1925, B, 992.) The control of its components is dealt with by A. W. Comber (*Chem. and Ind.,* 1927, **46,** 661).

Another cement, said to be impervious to water and oils, consists of a mixture of chloride of zinc or magnesium and ammonium with oxide of magnesium or zinc, which interact, forming oxychlorides, to which hardening agents, such as powdered glass, sodium biborate, silica, and flowers of zinc are added. The ammonium chloride retards the setting, so that the mixture may be readily applied by brush or trowel, and a small addition of zinc sulphate still further retards the setting. Contact with water increases the hardness when once set. (See Xylolith.)

SORGHUM (**Durra-Sorgho, Sorghum Saccharatum, Kafir, Indian Millet**)—A sugar-producing grass resembling maize in appearance, cultivated in the U.S.A., and used for human food, cattle-feeding, and various industrial purposes, but not suitable for malting. Several species are cultivated in Asia and Africa, particularly the *S. vulgare.* The following percentage table is extracted from published analyses:

	Protein.	Starch.	Pentosans.
Kafir kernels (*S. caffrorum*)	12·70	61·90	3·30
Milo ,, ...	13·99	68·52	3·93
Feterita ,, ...	16·69	64·16	3·38

SORGHUM (*Continued*)—

According to C. K. McClelland, "Honey Sorghum" yields 15 to 238 (average 75) gallons of syrup per acre, and 30 to 45 per cent. of the cane weight is obtained as juice, the sugar content being 5·7 to 14·7 per cent. (*B.C.A.*, 1930, B, 635).

Sorghum is largely used for the production of syrup.

The meal does not make good bread, but is stated to be an excellent substitute for rice in puddings.

SORPTION—See *Sorption of Gases by Solids,* by J. W. McBain (Routledge, London), and Colloid Chemistry.

SORREL (WOOD) (*Oxalis acetosella,* N.O. Oxalideæ)—A plant, native of Britain, which, in common with other *oxalis* and *rumex,* contains potassium oxalate, and is used in medicine. Twenty pounds of fresh leaves of the *O. acetosella* are stated to yield two ounces of potassium binoxalate. (See P. Sors on "Sorrels: New Tanning Plants" (*B.C.A.*, 1930, B, 1040).)

SOUND—See Light, p. 534.

SOXHLET APPARATUS—A glass appliance used for the extraction of soluble parts of substances, such as fat from milk, by the action of volatile solvents (absorbed in filter paper). An improvement on the ordinary type is described by R. C. Baker (*J.S.C.I.*, 1931, **50,** 54 T).

SOYA-BEAN OIL—A Chinese and Japanese product expressed from soya beans (*Soja hispida* and *S. japonica,* N.O. Leguminosæ), the Manchuria bean production in 1925 amounting to 3·7 million tons and the estimated world's annual production being about 4,189,333 tons. It is used as an illuminant, also in margarine and soap-making, as a cattle food, oil in varnish-making, and in the preparation of so-termed synthetic milk and cream. The cultivation of soya beans in the U.S.A. is rapidly expanding, and is also carried on in India, Ceylon, South Africa, Australia, and South America; it is also reported that some successful attempts are being made to cultivate a variety of the beans in this country. The percentage of oil in the beans varies from 14·6 to 25·6, and they are said to be rich in vitamins.

The oil has a pleasant odour and taste, is light brown in colour, and is generally credited with a sp. gr. of from 0·920 to 0·926 at 15·5° C.; m.p. 28° C.; sap. v. 185 to 195; i.v. 128 to 135; ref. ind. 1·4673 at 40° C.; acid value 4; acet. value 17; and solidifying-point of −8° C. (See also W. Kimura (*Analyst,* 1930, **55,** 703).)

One published analysis of the mammoth yellow variety gives a composition to the oil of 83·5 per cent. unsaturated acids, 11·5 per cent. saturated acids, and containing glycerides of linolinic acid 2·35 per cent., linolic acid 51·5 per cent., oleic acid 33·4 per cent., palmitic acid 6·8 per cent., stearic acid 4·4 per cent., arachidic acid 0·7 per cent., and lignoceric acid 0·1 per cent.

Another analysis of this oil (by H. Peahler) is as follows: linolenic acid 1·9 per cent.; linoleic acid 29·2 per cent.; *iso*linoleic acid (including a little *iso*linolenic acid) 24·3 per cent.; oleic acid 30·8 per cent.; stearic

SOYA-BEAN OIL (*Continued*)—

acid 7·0 per cent.; palmitic acid 2·35 per cent.; glyceryl residue (as C_3H_2) 3·88 per cent.; and unsaponifiable matter 0·5 per cent. (*B.C.A.*, 1926, B, 413). An analysis of the insoluble fatty acids of soya-bean oil (variety not named) is as follows: palmitic acid 10 per cent.; stearic acid 2 per cent.; arachidic acid 1 per cent.; lignoceric, linolenic, linolic, and oleic acids 88 per cent. (*Analyst*, 1924, **49,** 533).

The cold-pressed oil is converted into a thick viscid product of sp. gr. 0·96 or over by heating it to 500° C. for from five to seven hours, and a liquid resembling petroleum is stated to result from heating a mixture of the oil and finely powdered Japanese acid clay at 700° C., also from the dry distillation of the calcium salts of the fatty acids of the oil.

The composition of soya beans varies a good deal with the several varieties. (See Smetham and Dodd, *Royal Lancashire Agricultural Society Journal,* 1928.) Analyses of black and yellow soya beans from Bulgaria have shown them to contain 10·91 per cent. water, 36·76 per cent. protein, 18·57 per cent. fat, 25·27 per cent. nitrogen-free extract, 3·94 per cent. crude fibre, and 4·75 per cent. ash; while samples of artificial milk made from the same beans gave on analysis 90·53 per cent. and 88·19 per cent. water, 5·3 and 6·04 per cent. protein, 2·21 and 2·94 per cent. fat, 1·18 and 1·90 per cent. carbohydrates, and 0·78 and 0·93 per cent. ash.

Both the beans and the oil are staple articles of food in China and Japan, also the residual cake after extraction of the oil, while in England the oil is chiefly used for soap-making, and, it is said, to some extent as a substitute for linseed, rape, and cotton-seed oils in respect of their various applications, although, according to N. Belyaev, it cannot be used as a substitute for linseed or hemp-seed oil in paints (*B.C.A.*, 1930, B, 1038).

Soya-bean flour can be utilized in some measure for incorporation with ordinary flour in bread-making, and a good sauce (soy) of the "Worcester" type can be made from a mixture of soya beans and roasted wheat by subjecting it to mould fermentation, and then to prolonged maturing in brine.

The protein content is termed glycinin, from which an artificial sort of tortoiseshell can be made by the action of formaldehyde, and it can otherwise be used in compounding a number of useful articles.

The cake is a valuable cattle food and a useful fertilizer.

(See account of the properties and uses of soya-bean oil, by A. A. Horvath, taken from the *Chinese Economical Journal* by *C.T.J.*, 1930, **86,** 325, 363, and 378; the characteristics of polymerized soya-bean oil, produced by heating at 290° to 295° in carbon dioxide, by Hirose and Y. Takayama (*B.C.A.*, 1930, B, 753); "Composition of Soya-Bean Protein," by M. Mashino (*B.C.A.*, 1932, A, 182); and *The Soya Bean and the New Soya Flour,* by C. J. Ferrée (W. Heinemann, Ltd.).)

SPACE—The field hypothetically assumed to be occupied by the æther. (See articles by Einstein (*Times,* February 6 and 7, 1929); also Ether.)

SPACE FORMULÆ—See Formulæ and Stereo-chemistry.

SPALLING—See Refractories, p. 756.

SPANISH FLIES—See Cantharides.

SPARTEINE SULPHATE—A salt of sparteine ($C_{15}H_{26}N_2$)—a liquid alkaloid extracted from the tops of *Spartium scoparium* (broom), also present in the flowers of *S. junceum;* soluble in alcohol, and used in medicine. It can be prepared from lupanine and has been isolated in considerable amount from technical chelidonium residues (*Chelidonium majus*). (See Späth and Kuffner (*B.C.A.*, 1931, A, 854); also references to Clemo's papers under heading of Lupanine (p. 552); *J.C.S.*, 1931, p. 429; Winterfeld (*B.C.A.*, 1928, A, 906; 1930, A, 1300); and P. Karrer and associates (*B.C.A.*, 1931, A, 241).)

SPAS (and Medicinal Waters)—See *International Register* (International Soc. of Medical Hydrology, 55, Wellington Road, London, N.W. 8); also *Analyst*, 1931, **56,** 745 and 776; and Water, p. 972.

SPATHIC IRON ORE—See Iron, p. 491, and Siderite.

SPATULAS—Flat blades used for transferring solid or pasty substances from one container to another; made of various materials—some of steel fixed in a wooden handle, others of glass, ivory, platinum, nickel, aluminium, etc.; and used according to the nature of the substance to be manipulated.

SPEARMINT OIL or "GREEN MINT OIL"—A colourless essential oil containing terpineol, cineole, linalol, carvone, etc., distilled (1·0 per cent.) from the fresh American herb *Mentha viridis,* N.O. Labiatæ (ordinary garden mint), the German *M. crispa,* and Cape Province *M. longifolia*; sp. gr. 0·92 to 0·947 at 15° C., opt. rot. $-36°$ to $-48°$, ref. ind. 1·481 to 1·487 at 25° C., used in medicine as a stimulant, also for flavouring, and in confectionery. (See Peppermint Oil.)

SPECIFICATIONS—See Standard Specifications.

SPECIFIC GRAVITIES—The relative weights of equal volumes of gases compared with hydrogen at 0° C. and 760 mm. as unit are known as their specific gravities or vapour densities. The specific gravities of liquids and solids are their relative weights as compared with the density of water at 4° C. as the unit. (See Vapour Densities.)

A method largely used for determining the sp. gr. of solids, particularly in respect of samples of woods, is that of weighing the volume of water bodily displaced and dividing the number so obtained into the weight of the body in air. A more exact method is that of weighing the solid body in air and then in water, subtracting the latter from the former and dividing the difference—that is, the weight of the water displaced—into the weight-in-air of the body. Mr. Benton, whose paper is referred to below, describes a number of recently devised improved appliances useful for determining the sp. gr.s of gases, liquids, and solids. A balance for the determination of the sp. gr. of gases is illustrated (*Ind. Chem.*, 1930, vi., 470).

For determining the specific gravity of fluids by weight it is usual to employ a stoppered flask filled at 15·5° C., the stopper being inserted

SPECIFIC GRAVITIES (*Continued*)—
so that the liquid overflows and no air is left in the flask. Its weight (after drying externally) compared with that of water determines the relative weight. The weight of the liquid (after deducting that of the empty dry flask) having been ascertained, and that of the same quantity of water at the same temperature and pressure being known, the specific gravity of the liquid is ascertained by dividing it by the latter. An instrument for giving a continuous record of the specific gravity of liquids regardless of temperature is described (*Ind. Chem.*, 1926, ii., 341); see also W. A. Benton on "Modern Methods of Ascertaining Specific Gravity" (*Chem. and Ind.*, 1929, **48,** 1145), and Hydrometer.

SPECIFIC HEATS—See Heat, p. 440.

SPECTROGRAPH—See Light, p. 538.

SPECTROSCOPY—See H. Dingle (*Chem. and Ind.*, 1925, **44,** 602, 621, 651, and 674); F. Twyman on "Absorption Spectrography" (*Chem. and Ind.*, 1930, **49,** 535, 556, and 578); "Quantitative Spectroscopy," by S. J. Lewis (*Chem. and Ind.*, 1932, **51,** 271); Twyman and Smith's *Wave-length Tables for Spectrum Analysis,* 2nd edit., 1931 (Adam Hilger, Ltd., London); E. C. C. Baly's work (Longmans and Co.); *The Spectroscopy of X-rays,* by M. Siegbahn (Oxford Univ. Press); also Light (p. 536).

SPECTRUM—See Light (Spectroscope, p. 536).

SPECULAR IRON ORE (**Red Hæmatite**)—See Iron, p. 491.

"SPECULUM" METAL—An alloy of about 126 parts copper and 59 tin, used for making the mirrors of reflecting telescopes, etc., but now largely superseded by silvered glass.

SPEISS COBALT—See Cobalt.

SPELTER—A commercial name for zinc.

SPENCE METAL—Made by melting iron sulphide with sulphur in such proportions as to melt at about 320° F.; used for making busts and medallions and as a jointing material for pipes, etc.

SPENT OXIDE—Its use as material for the manufacture of sulphuric acid by the chamber process is described by W. H. Ibbotson (*Ind. Chem.*, 1928, iv., 513). (See also P. Parish on its analysis, etc. (*J.S.C.I.*, 1925, **44,** 307 T); Gas (Coal, p. 386), Sulphur (p. 872), and Tetralin.)

SPERM OIL—See Fish Oils, p. 534.

SPERMACETI—See Waxes.

"SPERMINE" (SPERMATIN) ($C_{10}H_{26}N_4$)—A crystalline base (isolated as phosphate) from testes, ovary, spleen, pancreas, thyroid, thymus, brain, and distillers' yeast. (See O. Rosenheim (*Biochem. J.*, **18,** No. 6, 1924); Dudley, Rosenheim, and Starling (*Ibid.*, Vol. 20, No. 5, 1926; also F. Wrede and others (*B.C.A.*, 1927, A, 264 and 651).) Spermidine is the name given to a closely associated base. (Dudley and others, *B.C.A.*, 1927, A, 243.)

SPERRYLITE—A rare mineral containing platinum diarsenide ($PtAs_2$) occurring in Ontario, Wyoming, the Transvaal, etc. A sulpharsenide of platinum has been discovered containing 64·2 per cent. platinum, 9·4 palladium, 17·7 sulphur, and 7·7 per cent. arsenic.

SPHAGNUM—A club moss (*Sph. acutifolium*) which grows abundantly in bogs on peat moors, and which has proved of great utility as a soft, absorbent, surgical dressing of mildly antiseptic character. Sphagnum peat is stated to contain 40 per cent. humic acid.

SPHALERITE (**Black Jack**)—Mineral zinc sulphide or zinc blende. An analysis by F. Ulrich and V. Veselij gives it the composition (9ZnSFeS). (See *B.C.A.*, 1928, A, 1350.)

SPIKE OIL—See Lavender (Spike) Oil.

SPINACENE—See Shark Oil (p. 353) and Squalene.

SPINELLE (**Spinel**)—A natural crystalline magnesium aluminate (MgO,Al_2O_3), used as a gem and as an abrasive (crystal system, No. 1, and sp. gr. 3·5). There are a number of varieties of different colours; found in Ceylon and elsewhere; varying also to some extent in composition. (See L. Passerini, *B.C.A.*, 1930, A, 1007.)

SPINTHARISCOPE—Apparatus for detection of *a*-rays as emitted from radio-active substances. An improved type for use in samples of air is described by Mangan and Schlundt (*B.C.A.*, 1931, A, 815).

SPIRITS OF WINE—Alcohol of indefinite strength. The spirits distilled in Great Britain during 1927 was 27,780,000 gallons. (See Alcohol.)

SPODUMENE—Lithium-aluminium silicate, $Li_2O.Al_2O_34SiO_2$, containing about 8 per cent. lithium, found in California, etc.; crystal system, No. 5, and sp. gr. 3·1 to 3·2.

"SPONDITE"—See Cellulose Acetate.

SPONGES (*Porifera*) are organisms of various species (found adherent to rocks in the Mediterranean and elsewhere), the tissues of which, constitutionally, are, from a chemical point of view, nearly related to the fibroin of silk. Spongia from *Hippospongia equina* is stated by V. J. Clancey to yield, upon hydrolysis, mainly glutamic acid and glycine, with smaller quantities of leucine, aspartic acid and other substances. (*B.C.A.*, 1927, A, 65.)

SPONGY PLATINUM—See Platinum and Catalysis (p. 153).

SPONTANEOUS COMBUSTION ensues as a result of the development of heat arising from chemical changes; thus, cotton waste soaked in linseed oil will sometimes fire in consequence of the rapid oxidation of the oil. Coal will sometimes pass into spontaneous combustion, due to fineness of condition and its "reactive" constituents—viz., those convertible into alkali-soluble ulmins by mild oxidation. (See Coal, p. 205; *B.C.A.*, 1926, p. 1000; and C. A. Browne on "Spontaneous Combustion of Hay" (*B.C.A.*, 1929, B, 1048).) Similarly, phosphorus exposed to the air will take fire, and burnt lime during slaking with water develops enough heat to fire wood that may happen to be in close contiguity.

SPRAY DRYING—See Drying.

SPRAYS—See Wetters.

SPRENGEL PUMP—See Pumps (Exhaust).

SPRUCE OIL—Distilled from the leaves and twigs of certain fir-trees (*Picea alba* and *P. nigra*). It contains pinene, cadinene, and bornyl acetate; is colourless, of pleasant odour; sp. gr. about 0·9; opt. rot. $-22°$ to $-25°$; soluble in alcohol and ether, and used in medicine and perfumery.

SQUALENE is a colourless oil (described as a precursor of cholesterol) of b.p. 240° to 242° C. at 2 mm., and i.v. 377·6, being an unsaponifiable hydrocarbon constituent of shark and other elasmobranch fish liver oils, the content amounting in some cases to 80 per cent., to which at one time the molecular formula $C_{30}H_{50}$ was assigned. It is said to closely resemble spinacene, to which A. C. Chapman has given the formula $C_{29}H_{48}$, but later observations point to the conclusion that these substances are possibly mixtures of homologues ranging from $C_{28}H_{46}$ to $C_{31}H_{52}$. Another investigation by Kamm and Owens is stated to have furnished proof that only one hydrocarbon is contained in these oils, of molecular formula $C_{30}H_{50}$, being a typical dihydrotriterpene. (See A. C. Chapman (*J.C.S.*, 1923, **123**, 769); *J.S.C.I.*, 1926, **45**, 181 and 184; Heilbron, Kamm, and Owens (*J.C.S.*, 1926, p. 1630); Heilbron, Hilditch, and Kamm (*J.C.S.*, 1926, p. 3131); Heilbron and others (*J.C.S.*, 1929, pp. 873-892); P. Karrer and others (*B.C.A.*, 1930, A, 1423, and 1931, A, 333 (in which the synthesis of the substance is discussed and the formula given as $(CMe_2 : [CH{\cdot}CH_2{\cdot}CH_2{\cdot}CMe]_2 : CH{\cdot}CH_2{\cdot})_2$); "Contribution to the Study of the Origin of Petroleum," etc., by Ormandy, Craven, Heilbron, and Channon (*C.T.J.*, 1926, **79**, 705); and Shark Oil, p. 353.)

SQUALUS LIVER OIL—See Fish Oils, p. 353.

SQUILL—The dried bulb of *Urginea scilla,* N.O. Liliaceæ, from Mediterranean and Caucasian areas, collected in Sicily and Malta, containing bitter glucosides, and used chiefly in India as a drug. Red squill (*U. maritima*) in powder form is used as a raticide, its glucosidal content being named xanthoscillid. There is an African variety known as *U. Burkei,* Baker, and three species occur in England and Scotland.

Medicines used as diuretics and expectorants are prepared from the drug, which is of a dangerous character in many respects.

"S.R.A." COLOURS—See Dyes and Silk Substitutes, p. 813.

"STABILARSAN"—An anti-syphilitic product of glucoside character, soluble in water, and which hydrolyses with precipitation of salvarsan base.

STAINLESS STEEL—See Rustless Iron and Steel.

STAINS may be more or less removed from materials by various means of a physical and chemical nature. Where solids are concerned attrition with kieselgühr, rubber, bread, or pumice stone, etc., will sometimes remove surface deposits; in other cases of a greasy character, solvents can be employed, such as alcohol, petrol, turpentine, and carbon tetra-

STAINS (*Continued*)—

chloride, regard always being had to the nature of the stains; while in yet other instances, the removal must be based upon consideration of chemical reactions.

Ordinary ink stains can be removed from certain materials by the use of oxalic acid solution; fruit stains by the use of hydrogen dioxide; rust stains on cloth by the solvent action of solutions of magnesium and sodium fluosilicate—that is, immersion in the warm fluid of 3 to 6 per cent. strength, followed by immediate rinsing in hot water and subsequent passage through a dilute solution of sodium carbonate. Verdigris stains on cloth may be removed by saturation with ammonia, rubbing with a cloth soaked in ammonia, and treatment with a hot solution of potassium fluoride, or a cold solution of dilute hydrochloric acid. (For removal of stains from hosiery goods see H. L. Long (*J. Soc. Dyers and Col.*, 1931, **47**, 287) and for Microscopic Stains see Microscopes.)

STALACTITES—Deposits of calcium carbonate like icicles, formed by dripping water from the roofs of calcareous caves, due to evaporation of water and the escape of carbon dioxide from the solution of calcium carbonate dissolved in water and previously held in solution by its agency.

STALAGMITES—Similar deposits to stalactites growing upon the floor of caves out of the water dropped from above (by evaporation).

STALAGMOMETER—Instrument for measuring surface tension by the drop method. (See Colloid Chemistry, p. 228.)

"STALLOY"—A silicon-iron alloy used in the electrical industry.

STANDARD SOLUTIONS—See Reagents and Volumetric Analyses.

STANDARD SPECIFICATIONS—A number of these are issued by the B.E.S.A., of 28, Victoria Street, Westminster, S.W., applicable to cements, coal, coke, steel cylinders, solders, ebonite, chemical lead, road-tars, forgings, castings, lead, white spirit, paints, regulus metals, bronze A, various steels, turpentines, colours, lubricating and other oils (used for paint-making and varnish) viscosity, etc. Some 378 specifications are available, and also a complete index (1930 edit.).

STANDARDS (**Analytical**)—See address by E. Hinks (*Analyst,* 1930, **55,** 242; *Chem. and Ind.*, 1932, **51,** 103) and the B.D.H. Book of A.R. Standards (British Drug Houses, Ltd., London).

STANNATES—See Tin Compounds.

STANNIC ACID—See Tin Compounds.

STANNIFORM (**Methyl Stannic Iodide,** $CH_3.SnI_3$)—Yellow crystalline substance, m.p. 87° C., applied in therapeutics (1929) as antiphlogistic, analgesic, and antiseptic. It combines the usefulness of tin in staphyloccic infection with the powerful germicidal properties of iodine.

STANNITES—See Tin.

STAR-ANISE OIL—See Duncan, Sherwood, and Short (*J.S.C.I.*, 1931, **50,** 410 T), and Aniseed Oil.

STARCH (**Amylum**) is found present in some of the parts of nearly all plants, in the form of organized or structural granules of varying size, and abundantly in wheat, maize, barley, oats, arrowroot, rice, and potatoes. Chemically, starches are carbohydrates (polysaccharides), their essential structure being probably based upon glucose. The formula $(C_6H_{10}O_5)_n$ represents the proportions of the constituent elements, the number in the molecule being unknown—and starch constitutes the source from which the sugar content of plants is derived during the transference of the sap.

One supposition is that starch is composed of conjugated maltose units joined by covalent links (Haworth). A. Pictet considers that starch has a high molecular weight and is a polyhexosan—*i.e.*, a polymerization product of a hexosan (*B.C.A.*, 1929, B, 695). According to Maquenne and Roux the inner part of starch granules consists of a substance named "amylocellulose" or "amylose," which is completely converted into maltose by the agency of malt diastase, and that the exterior portion, amounting to 20 per cent. and named "amylopectin," is that to which the property of starch of forming a viscous paste is due. (See A. R. Ling (*Chem. and Ind.*, 1928, **47,** 1308, and 1929, **48,** 291; and Polak and Tychowski, *B.C.A.*, 1929, A, 1488).)

The results of some experiments made with the amylases obtained from rye, barley, and oats before and after germination appear irreconcilable with the view that the starch molecule is composed of amylase and amylopectin. Baker and Hulton question, therefore, the views of Maquenne and Roux, elaborated by Ling and Nanji, and are of opinion that their own results support the older hypothesis that starch consists of condensed maltose residues (*J.C.S.*, 1929, pp. 1650-1660; see also J. Effront, *B.C.A.*, 1931, A, 469).

It has also been represented that the starch granules of barley, wheat, rice, and some other cereals contain a third substance named amylochemic cellulose, equally admitting of complete conversion into maltose by both forms of diastase. (See Beer.)

For an account of researches carried on by the British School of Malting and Brewing and Department of the Biochemistry of Fermentation at Birmingham see *Chem. and Ind.*, 1931, **50,** 2.

Potatoes contain from about 17 to 27 per cent. of starch; wheat from 50 to 75 per cent.; barley and oats about 60 per cent.; maize about 67 per cent.; rice about 76 per cent. A large quantity of potato starch is exported from Poland.

Rice starch and that of maize are largely used in preparing the so-called "cornflours."

Sago is a starch produced from the pith of the stems of the sago-palm; tapioca and cassava are made from the *Jatropha manihot;* arrowroot is the starch of the tropical plant *Maranta arundinacea,* and other species of the N.O. Scitaminea, and has been used as a binder for briquettes; while arum is a starch similar to sago obtained from the root of *Arum maculatum.*

STARCH (*Continued*)—

It is stated that wheat starch grains vary in diameter from 15 to 45 microns, whereas those from barley never exceed 40 microns.

Lichenin—otherwise known as *moss starch* (said to be identical with starch amylose and which can be completely hydrolysed to maltose)—is contained in many lichens, including Iceland moss; inulin is another variety present in dahlia and other roots; whilst glycogen is a form of animal starch found in the livers of mammalia.

The amount of starch contained in barley and wheat can be estimated by the amount of maltose produced at the end of a given time (say, one hour) by the action of malt diastase.

Starch is not soluble in cold water, but when heated with water it swells up and assumes a more or less pasty condition, forming a kind of emulsion, commonly known in chemical laboratories as "starch solution," although but little passes into real solution. This swelling is stated to result from the hydration and dehydration respectively of the molecules.

There is a commercial demand for so-called "cold-water starch," forming viscous solutions with cold water, and these, as a rule, are prepared by the action of acids, alkalies, or hydrolysts. Modified starches soluble in water may be made by the action of diastase. (See S. R. Trotman, *Ind. Chem.*, 1928, iv., 399.) Processes for the liquefaction and decomposition of starch by biolase and its use in the paper industry are also described by H. Wrede (*B.C.A.*, 1929, B, 450).

If ground in a mortar until most of the granules are injured, it is stated to become incapable of yielding paste in ordinary concentration, although still recognizable as starch under the microscope, most of the granules having become colloidally soluble in cold water (C. L. Alsberg, *B.C.A.*, 1926, B, 336).

As Thudichum has pointed out (in his *Annals of Chemical Medicine*, vol. i. (Longmans and Co.), the transformation of starch into glucose, etc., is accompanied by the loss of colloidal state and away from the organo-plastic condition, the products being fit for the production of power by oxidation, but unfit for the formation of organs in the animal economy. (See "The Hydrolysis of Starch by Acids," by D. R. Nanji and R. G. L. Beazeley, *J.S.C.I.*, 1926, **45,** 215 T.)

If starch be heated in the dry state for some hours at a temperature of 200° C., its character becomes changed, and the product, which is quite soluble in water, is known commercially as dextrine or British gum—as used by calico-printers for mixing with their colours, also as an adhesive, for sizing, and other purposes. It is also prepared from starch by action of a small quantity of acid at 150° C., and by the action of malt extract, which produces dextrine in association with dextrose. One manufacturing plant used commercially is known as the "Dextrine Automat." (See Dextrines and Dextrose.)

By the action of dilute acids and ferments, starch yields a number of sugar-like bodies known as dextrose, maltose, etc., which are largely employed in brewing fermentation and other industries. Both in its soluble and insoluble conditions, starch combines with

STARCH (*Continued*)—

iodine, forming a deep blue compound, but inulin is coloured yellow by iodine. H. D. Murray suggests that an additive compound is formed by starch with iodine, "the union of which in dilute potassium iodide solution has the formula $(C_6H_{10}O_5)_nI_5$, where n is approximately 15."

By acetylation, starch can be converted into a number of so-called acetates, including an acetylated dextrine, and one such product is described under the heading of "Feculose," while by a special process of fermentation, acetone is commercially prepared from starch.

From recent research work it would appear that a synthetic starch has been made.

Starch in its various forms is used in laundries for glazing linen and the finishing of textiles; also as a filler in compounding cocoa preparations, the manufacture of adhesives, explosives, invalids' foods, dextrine, as a binding material, and as a face-powder, etc.

See "Studies on Starch," by A. R. Ling and D. R. Nanji (*J.C.S.*, 1925, cxxvii., 629 and 656); A. R. Ling (*J.S.C.I.*, 1927, p. 279 T); H. Pringsheim (with others) on "New Polyamyloses" (*B.C.A.*, 1930, A, 1561; *Chem. and Ind.*, 1927, **46**, 1204); "Constitution of Starch," by Meyer (with others) (*B.C.A.*, 1929, A, 799); "Maize Starch," by T. McCurdie (*C.T.J.*, December 12, 1924); "Behaviour of Various Starches towards Dyestuffs and Iodine," by J. Huebner and V. Veukataraman (*Analyst*, 1927, **52**, 37); "Microscopic Examination of Starches and Flours," by W. Garner (*Ind. Chem.*, 1929, v., 119); "Modern Methods of Manufacture," by "Omega" (*C.T.J.*, 1926, **79**, 219); Petit and Richards on "Mechanical Liquefaction of Starch" (*B.C.A.*, 1926, A, 502); E. Peiser on "Structure of Starch based upon its Acetylation" (*B.C.A.*, 1927, A, 136); W. Eckard on the "Adhesive Power of Starch" (*B.C.A.*, 1929, B, 298); "Determination of Starch in Cereal Products," by Herd and Kent-Jones (*J.S.C.I.*, 1931, **50**, 15 T); article on the World's Starch Trade, by J. le Clerc (*C.T.J.*, 1927, **80**, 6); *Starch Making*, by F. Rehwald, translated by C. Salter (Scott, Greenwood and Son); *A Comprehensive Survey of Starch Chemistry*, by R. P. Walton (Chem. Catalog. Co., Inc., N.Y., 1928); *Starch: its Chemistry*, etc., by L. Eynon and J. H. Lane (W. Heffer and Sons, Ltd., Cambridge); "Aktivin," Beer, Carbohydrates, Glucose, Potato, Rice, and Wheat.

STASSFURT SALTS—The dried-up residue of a great prehistoric ocean, containing from 9 to 15 per cent. pure potash, and utilized for the preparation of various potassium salts; the output in 1925 was about 12,000,000 metric tons. (See Carnallite, Sylvine, Kainite, Kieserite, and Potassium.)

"STAYBRITE"—A make of acid-resisting rustless metal (chromium-nickel steel) having a yield-point of 15 to 17·5 tons per square inch. The carbon content in the standard material is about 0·30 per cent., so that it hardens well, while the sp. gr. is slightly less than that of mild steel, varying with grades from 7·726 (a hard variety) to 7·925 (a soft variety). The mechanical, physical, and corrosion-resisting

" STAYBRITE " (*Continued*)—
properties of the several varieties are described in the manufacturers' publications. In certain makes proportions of tungsten and silicon are added to impart additional strength at high temperatures.

STEAM—Heat to the extent of 970·4 B.Th.U.s is required to convert 1 lb. water into 1 lb. steam at atmospheric pressure in the process of evaporation (A. J. V. Underwood), and it has been estimated that some 650,000,000 tons of coal and lignite are burned annually in the world for steam generation.

For economy, the coal selected should have the lowest volatile-matter content possible, consistent with existing conditions, and a minimum of ash-content; the highest possible calorific value per unit of price; it should not form a dense coke, nor be used in larger than 4-inch cobbles.

Mr. Brownlie states that probably 75 per cent. of the steam used in Great Britain is still generated in Lancashire boilers at pressures varying from 60 to 200 lbs. per square inch, and that only about 20 per cent. thermal efficiency is obtained from the raw coal for a few of the latest super-power stations, 10 to 12 per cent. for the better class of large reciprocating engines, 7 to 8 per cent. for the ordinary industrial condensing steam engine, and 4 to 5 per cent. for the steam locomotive.

By means of steam accumulation, boilers will function as steam generators working always at their maximum efficiency, and restricted steam supply is thus obviated (Stanley Hopkins, *J.S.C.I.*, 1925, **44,** 69 T). The description of a steam accumulator as an aid to economy in the dye-house has been given by Dr. Ritchie (*Chem. and Ind.*, 1929, **48**, 242). "Ruth's Steam Accumulator" enables a boiler to work for the average demand, maintaining an unvarying pressure and temperature in the low-pressure steam mains, thus making for uniform production under conditions that eliminate the production of smoke. The "Kiesselbach" accumulator is another variety.

Great improvements have been made in both internal combustion engines and steam engines in recent years, the rivalry between the two being largely due, it is stated, to the fact that the most efficient kind of the former (Diesel engines) convert a greater portion of the fuel heat into energy than the other sort.

A running efficiency of 90 per cent. can be obtained with both pulverized fuel and mechanical stoking, as, for example, with the "Murray" water-cooled fire-tube furnace, described by David Brownlie (*Chem. and Ind.*, 1926, **45,** 21).

A common pressure is about 500 lbs. per square inch, although in some modern plants 1,500 lbs. pressure is realized, the temperature of the steam ranging from 316° to 426° C. (600° to 800° F.), thus ensuring a good thermal efficiency.

The use of steam of high pressure is greatly increasing, so that the temperature sometimes used approaches that of red-hot pipes (540° C.), and it is thought that much higher pressures and temperatures made possible by the use of alloy steels may place the steam engine in a higher position as regards economy of fuel. The object of generating

STEAM (*Continued*)—

steam at an enormous pressure is to use it in an engine or turbine, and to exhaust at normal pressure for ordinary use, employing therefor a back-pressure reciprocating engine or a condensing quadruple expanding steam engine.

Among new boilers are the "Broido," the "Becker" flash boiler, "Blonquist" revolving boiler at 1,500 lbs., and the "Brunler"—a form of internal combustion type described in the *C.T.J.*, 1925, **76,** 10, and by Oscar Brunler (*Chem. and Ind.*, 1925, **44,** 187, and *Ind. Chem.*, 1927, iii., 215); see also N. Swindin on submerged flame combustion (*Chem. and Ind.*, 1927, **46,** 1179), in which a flame is used in water; C. F. Hammond on the application of submerged combustion to phosphoric acid concentration, in which a thermal efficiency of 90 per cent. is claimed as realizable on the net calorific value of the fuel gas as used (*C.T.J.*, 1931, **88,** 302), and report of discussion thereon (*Ibid.*, 1931, **88,** 384). *Other references: Ind. Chem.*, 1928, iv., 467; *Ibid.*, 1929, v., 529; *Chem. and Ind.*, 1931, **50,** 733; and Hammond Burner.

The "Benson" super-pressure generator is one in which a narrow-bore coil is employed wherewith water is converted into dry saturated steam under the actual critical conditions of 3,200 lbs. per square inch pressure and about 375° C., thus eliminating ebullition altogether and enabling about 30 to 35 per cent. thermal efficiency to be obtained from the raw coal.

It has been proved that between 400° and 500° C. a slow decomposition of steam takes place, and that this change becomes rapid above 500° C.

Another system of steam generation which is attracting some attention employs the use of some material of high boiling-point, such as metallic mercury or diphenyl oxide, which is first of all vapourized by direct heat, the vapour yielding its power by expansion in a turbine, the heat of the condensed material being used to generate steam in the ordinary way. This so-styled bi-fluid system is illustrated by the "Emmet" mercury vapour-steam boiler.

There are a number of methods for minimizing or preventing the formation of scale in boilers, some of which consist in introducing various preparations for producing a sludge with the mineral contents of the water, which can be blown off from time to time, including a method employed by "Filtrators, Limited, London," which employs linseed. (See *Ind. Chem.*, 1926, ii., 519.)

Calcium sulphate, calcium carbonate, silica, etc., are among the prominent components of boiler deposits or incrustations, and of these calcium sulphate (gypsum) is the most pernicious. It has been shown that "by maintaining correct ratios of the acidic ions in the feed water the incrusting solids are always thrown out of solution as a sludge and are not deposits upon the heating surfaces as scale." (See report of paper by W. S. Coates (*Chem. and Ind.*, 1929, **48,** 1134); R. Escourrou on "Prevention of Boiler Scale" (*B.C.A.*, 1930, B, 443); and E. Partridge (*B.C.A.*, 1930, B, 1133); and Christman (with others) (*B.C.A.*, 1931,

STEAM (*Continued*)—

B, 702). The "Thermofeed Regulator" is an appliance for governing the feed water of boilers, while the consumption of steam can be recorded by one known as the "Electroflo Meter."

The "Atlas" steam separator and dryer is designed for the purification of steam from solid impurities, and reduction of the moisture content to less than 0·5 per cent.

References: Description of a new steam meter (*Ind. Chem.*, 1925, i., 458); the "N.O.C." process for preventing scale deposition and boiler corrosion (*Ind. Chem.*, 1930, vi., 494); possibilities of high-pressure steam, by H. Griffiths (*Ind. Chem.*, 1928, iv., 61); notes on high-pressure vessels (*Ind. Chem.*, 1930, vi., 150); thermal storage (*Ind. Chem.*, 1930, vi., 63); boiler firing, by T. R. Wollaston (*Chem. and Ind.*, 1929, **48,** 426 and 1002); priming in boilers (in the view of Joseph and Hancock, due to the layer of bubbles on the water surface increasing in thickness and stability to an undue extent) (*J.S.C.I.*, 1927, p. 315 T); J. S. Hancock's observations on the priming of saline waters (*Ibid.*, 1930, **49,** 369 T); H. E. Jones on "Boiler Water Chemistry" (*Jl. Inst. Chem.*, June, 1931; *Chem. and Ind.*, 1931, **50,** 854, and 1932, **52,** 98); "Selection of Coal for Steam-raising," by G. W. Himus (*Ind. Chem.*, 1930, vi., 351); D. Brownlie on "Treatment of Boiler-Feed Water" (*Ind. Chem.*, 1926, ii., 274); "Modern Boiler Development and Feed Water Treatment," by W. S. Coates (*J.S.C.I.*, 1930, **49,** 206 T, 213 T, 230 T, and 241 T); "Waste Heat Boilers," by E. S. Davies (*B.C.A.*, 1931, B, 139); "Steam Production Costs," by H. C. Morris (*Chem. and Ind.*, 1927, **46,** 25; *Ind. Chem.*, 1931, vii., 517); *Steam Condensing Plant,* by J. Sims (Blackie and Sons, Ltd.); *Chemical Technology of Steam-raising Plant,* by H. N. Bassett (E. Arnold and Co., 1931); Steam, Water, and Water Softening.

STEARIC ACID ($C_{18}H_{36}O_2$ or $CH_3.(CH_2)_{16}CO_2H$)—A solid member of the normal fatty acids present in most animal and vegetable fats and oils, and generally associated in varying proportions with palmitic and oleic acids, all in combination with glycerol in the form of glycerides. It is most abundant in the more solid fats and forms hard soap when saponified, setting free the glycerol, as explained elsewhere. (See Soaps.) It can be readily prepared from beef or mutton fat, and when pure is white, crystalline, of sp. gr. 0·847 at its m.p. 69·3° C.; is soluble in alcohol and ether, and used in making soaps and candles and as a softener for rubber goods, etc. Its manufacture, economics, and uses form the subject of an American paper by D. F. Cranor (*C.T.J.*, 1929, **85,** 171), and the manufacturing methods used in the U.S.A. one of an article (*Ibid.*, 1930, **86,** 31); see also T. R. Olive (*B.C.A.*, 1930, B, 153).

Exposed to oxygen in presence of manganese stearate at 120° to 130° C., volatile acids, including acetic, formic, and butyric acids, are produced to some extent. The main oxidized product after washing has been found to have acid value 206 and sap. v. 244, and to contain some proportion of lactones (Salway and Williams).

Certain metallic stearates, such as those of calcium and aluminium,

STEARIC ACID (*Continued*)—
are recommended for use as metallic soaps, also as diluting agents in preference to hydrated lime, for admixture with Paris green as used for dusting to prevent the maturing of malaria-carrying mosquitoes. These compounds increase the floating power of the Paris green when used as dusting powder on water in pools and ponds. Some metallic stearates also find use as special lubricants and as driers and flatteners in paints and varnishes. (See Fats and Metallic Soaps, p. 823.)

STEARIN (**Stearine, Tristearin**) ($(C_{18}H_{35}O_2)_3C_3H_5$)—The glyceride or glyceryl ester of stearic acid, occurring as a solid constituent of fats, and yielding potassium stearate (soap) and glycerol upon saponification with alcoholic potash. Beef stearin melts at 71° C., has a sp. gr. 0·862, and is soluble in ether, chloroform, and carbon disulphide. Other commercial stearins have m.p. 120° to 122°, the melting-point being largely dependent upon the proportion of the stearic acid content. They are largely used in soap and candle making, also in the leather and tanning trades and in making polishes. A residual pitch, known as stearin pitch, is obtained by the distillation of fatty acids. (See A. Rayner, *C.T.J.*, 1928, **83**, 183, 205, and 289; Fats and Stearin Pitch, p. 709.)

" STEAROPODIO " is stated to consist essentially of magnesium stearate. It has great fineness and softness, and is used in making " solid " perfumes, soaps and skin creams, etc.

STEAROPTENES—The solid constituents of certain essential oils, the liquid parts being designated *eleoptenes* or *oleoptenes*. (See Attar of Roses.)

STEATITE (**Soapstone**)—A form of talc, found in many countries, slabs of which are often used for making firestones in furnaces and stoves, and in compressed powder form for making sparking-plugs. It is mechanically stronger than stoneware and can be machined with greater accuracy. It is also used for making electrical insulators, acetylene burners, in porcelain manufacture, and by tailors to mark cloth. (See article on " Steatite and Porcelain Products " (*Chem. and Ind.*, 1930, **49**, 433); description of a new works at Stourport (*Ind. Chem.*, 1930, vi., 233); French Chalk, Soapstone, and Talc.)

STEEL—See Iron and Rustless Iron.

STELLAR CHEMISTRY—See Light, p. 538.

" STELLITE "—A hard, star-like brilliant alloy of 75 parts cobalt and 25 parts chromium, with a proportion of tungsten or molybdenum, produced by melting them together in an electric furnace at over 1,500° C. It is made in two grades, and is used for high-speed cutting tools, making cutlery and surgical implements, scraping the scale off hot billets, and as a nitric acid resistant material. A newer application is to the wearing parts of machine parts, mill machines, oil drilling

"STELLITE" (*Continued*)—
equipment, and ploughshares by use of the oxyacetylene blowpipe or the electric arc. "Akrite" is a similar alloy. (See W. H. Losee (*J.S.C.I.*, 1925, **44,** 451 T), and Cobalt.)

"STELLITING"—See Metals, p. 577.

STEPHANITE ($5Ag_2S.Sb_2S_3$)—A native sulph-antimonite of silver (crystal system, No. 4, and sp. gr. 6·26) occurring in Freiburg, the Harz, Hungary, Colorado, Nevada, etc.

STERCULIA OIL from members of the *Sterculiaceæ,* N.O. Columniferæ, such as the *S. chica* and *S. lasiantha* of Brazil, yielded by both pericarp and kernel; the skin and pulp giving nearly 27 per cent., and kernels about 29 per cent. The pulp oil has a sp. gr. at 100° / 15·5° C. of 0·8561; sap. v. 191·2; and i.v. (Wijs) 69·7. The kernel oil has a sp. gr. of 0·8675, sap. v. 180·2, and i.v. 62·3.

STEREO-CHEMISTRY (Stereometry, Chemistry in Space)—The study of the relative positions occupied by atoms or groups in molecular bodies. It is alleged that by means of X rays Dr. Shearer has been able to analyze four fatty acids of composition unknown to him, and to determine in each case the number of carbon atoms in each chain and the position of the ketone oxygen. (See W. Bragg (*Chem. and Ind.*, 1926, **45,** 245); T. M. Lowry on "Recent Advances in Stereo-chemistry" (*Chem. and Ind.*, 1927, **46,** 78 and 102); editorial reference to Pope's researches (*Chem. and Ind.*, 1931, **50,** 1029); also Co-ordination, Formulæ, Isomerism, Rings, and X Rays.)

STEREO-ISOMERISM—See Isomerism.

STEREOMETER—Instrument for determining the sp. gr. of porous substances, powders, etc.

STEROLS—A group of unsaponifiable substances, or "lipids," such as the solid monohydric alcohols like cholesterol which occurs in many animal fats, the phytosterols which occur in vegetable oils and animal tissues in small proportion and myricyl alcohol. A method for separating the sterols from butter and other fats is given by Van Sillevoldt (*Analyst,* 1929, **54,** 735). Maize oil is said to contain 1·68 per cent. of "sitosterol" of m.p. 137·5° C. (isomeric with cholesterol)—see Sandqvist and Bengtsson on its composition (*B.C.A.*, 1931, A, 1289). Yeast contains ergosterol ($C_{27}H_{42}O$), while cotton-seed oil and linseed oil contain two "phytosterols" melting at about 134° to 138° respectively. (See Allan and Moore (*J.S.C.I.*, 1927, p. 433 T).)

"Zymosterol" ($C_{27}H_{42}OH_2O$) is the name given to a dextro-rotatory sterol of yeast (see Penau and Tanret (*B.C.A.*, 1929 A, 809) and Fabre and Simonnet (*Ibid.*, A, 809)), but later examinations by others make it appear that the correct formula is $C_{27}H_{44}O$. There are many isomers, it is supposed, of cholesterol, but the available data respecting them, although of biological importance, is very vague.

See Report of the Food Investigation Board for 1927 (Adastral House,

STEROLS (*Continued*)—

Kingsway, London); K. Bonstedt (*B.C.A.*, 1928, A, 892); Heilbron and Sexton (*J.C.S.*, 1929, p. 921); Heilbron, Sexton, and Spring (*Ibid.*, pp. 926 and 2807); Bose and Doran (*Ibid.*, p. 2244); Heilbron with others (*Ibid.*, pp. 2248 and 2255); Reindel and Weickmann (*B.C.A.*, 1929, A, 1443); Sandqvist and Gorton (*B.C.A.*, 1930, A, 1431); Wieland and Gough (*Ibid.*, A, 1431); Ergosterol, Ergot, Maize Oil, Vitamins, and Yeast.

STIBILITE—A native oxide of antimony (crystal system, No. 5).

STIBNITE (**Grey Antimony or Antimony Blende**)—Mineral antimony sulphide (Sb_2S_3); crystal system, No. 4, and sp. gr. 4·5. (See Antimony.)

STICK LAC—See Shellac.

STILBENE (**Diphenylethylene**) ($C_6H_5.CH:CH.C_6H_5$)—A nearly colourless, crystalline body of m.p. 124° C. and b.p. 306° C. prepared by the action of sodium upon benzyl dichloride ($C_6H_5.CHCl_2$) or by passing toluol over heated lead oxide. It is soluble in alcohol and ether, and is used in the dye industry.

STILBITE—A mineral, hydrated silicate of calcium and aluminium of zeolite character $(Na_2Ca)O,Al_2O_3.6SiO_2.6H_2O$; crystal system, No. 5, and sp. gr. about 2·0.

STILLINGIA OIL—See Vegetable Tallow.

STILLS—See Distillation and Retorts.

STIRRERS—See Mixers.

"**STOCKALITE**"—A proprietary brand of colloidal clay as required for use in rubber, paint, and toilet articles industries.

STOCKHOLM TAR—A tar of several grades distilled from the resinous wood of the pine, and largely used in connection with wooden shipbuilding for caulking, tarring ropes, making roofing compounds, and preserving timber. It is soluble in turpentine.

STOICHIOMETRY (**Chemical Mathematics**) deals with the numerical relationships of atoms and molecules of chemical bodies and their interactions. (See *Industrial Stoichiometry*, by W. K. Lewis and A. H. Radasch (Chem. Eng. Series, McGraw Hill Publishing Co., Ltd.).)

STONE—For constructional purposes, stone of various kinds is required for frontages, dressings, and some classes of engineering work; for random blocks and rubble; for use in making concrete pavements and roads; as slates for roofing, etc., and for calcination in making lime and cement. Among the kinds largely used are the carboniferous and triassic formations of hard and soft varieties of sandstone, which abound in Yorkshire, Lancashire, Cheshire, and elsewhere; the jurassic system of rocks, which furnish the best Portland stone and the softer Bath stones.

STONE (*Continued*)—

The carboniferous limestones yield also a closer-grained and heavier type, such as the Hopton Wood stone of Derbyshire. The somewhat similar but older limestone of Devon; the magnesium limestones of Derbyshire, Notts, and Yorkshire; the Ragstone of Kent; the warm, brown stone of Nutfield, and the fine granites of Cornwall, Devon, Westmorland, and Scotland, are others among many varieties of stone to be found in this country. (See Schönhöfer (*B.C.A.*, 1927, B, 938).)

STONE PRESERVATION—Among film applications used in respect of buildings are sodium silicate and gelatinous solutions (followed by spraying with formaldehyde to fix same). Creosote and many other preparations, which will cover the surfaces with a practically insoluble coating, may also be used (according to circumstances).

The "Fluoridation" method employs soluble fluorine salts which are said to leave the surfaces impervious to water and resistant to acidity of the atmosphere; zinc and magnesium silico-fluorides being among the agents employed.

In the U.S.A. resort is frequently made to the use of wax or a stearate dissolved in a volatile solvent applied with a brush or spray.

A. P. Laurie has experimented with a certain silicon ester made by the action of alcohol on silicon tetrachloride. It mixes readily with volatile solvents, and when exposed to air and moisture, deposits hydrated silica in transparent layers, so that it behaves (with certain limitations) as an efficient preservative to decaying stone. (See *Ind. Chem.*, 1930, vi., 112, and Silicon Esters.)

Attrition (brought about by wind, water, and changing temperatures) is the most potent destructive agent, while water acts as a bursting agency by freezing within the pores of stone and as a solvent in proportion as it contains sulphur oxides in solution. Carbon dioxide contained in air and water is also destructive, particularly of limestone, as it leads to the formation of calcium carbonate and its ultimate conversion in many instances into calcium sulphate, which is gradually dissolved and carried away.

From chemical considerations it does not appear likely that bacterial action can have any material influence in stone decay, although some attention has been paid to this subject with a more or less negative result. Alkaline washes (lime, potash, soda) are useful in giving some protection against attack by acids in the atmosphere. (See Report of a Government Committee appointed in December, 1922, summarized in *C.T.J.*, 1927, **80**, 503; Report of the Building Research Board for 1928 (H.M. Stationery Office); J. J. Fox and T. W. Harrison (*J.S.C.I.*, 1925, **44**, 145 T); A. R. Warnes (*Chem. and Ind.*, 1930, **49**, 324); and Sodium Silicate.)

STONEWARE is largely used in chemical industries. (See article by F. Weinreb on this subject (*Chem. and Ind.*, 1931, **50**, 213); also Clays, Porcelain, Refractories, Steatite, Soapstone, and Stone.)

STORAGE BATTERIES—See Electricity, p. 296.

STORAX (Styrax)—See Balsams and Styrene.

STOVAINE—A synthetic lumbar anæsthetic, being methyl-ethyl-dimethyl-aminomethyl-carbinyl benzoate ($C_6H_5.CO.O.CMeEt.CH_2.NMe_2.HCl$).

STRAIN THEORY—A valency deflection hypothesis. (See letter on this subject by Jocelyn Thorpe and C. K. Ingold (*Chem. and Ind.*, 1931, **50,** 464), and W. A. Wightman (*Chem. and Ind.*, 1931, **50,** 479).)

STRAMONIUM—The alkaloidal extract of the leaves of the British Columbian *Datura stramonium* (N.O. Solanaceæ and commonly known as the thorn-apple); it contains atropine, hyoscyamine and hyoscine. (See Atropine and Hyoscine.)

STRAW—A published ultimate analysis of straw is as follows: carbon 35 per cent.; hydrogen 5 per cent.; oxygen 38·5 per cent.; nitrogen 0·5 per cent.; water 16·5 per cent.; and ash 5 per cent. Apart from its other uses, straw, in the form of plaited rope, forms an excellent protective covering for waterpiping against frost, and is also used in making straw-board for cheap box-making. The dyeing of straw is described by E. Gilson (*Ind. Chem.*, 1928, iv., 224); and "Artificial Manure from Straw," by Collison and Conn (*B.C.A.*, 1930, B, 28). (See Feeding Stuffs and Sewage.)

STROMEYERITE—A mineral double sulphide of silver and copper (Ag_2S,Cu_2S) found in Arizona and elsewhere.

STRONTIANITE—See Strontium.

STRONTIUM (Sr) **and its Compounds**—Atomic weight 87·6; sp. gr. 2·54; m.p. 752° C.; b.p. 1,639 ± 5° C (Hartmann and Schneider, *B.C.A.*, 1929, A, 754); credited with three isotopes (86, 87, and 88). Strontium is contained as carbonate ($SrCO_3$) in the mineral known as *strontianite* (crystal system, No. 4, and sp. gr. about 3·6); in *brewsterite* as a complex silicate, and in *celestine* as sulphate ($SrSO_4$). Workable deposits of celestine are found in Canada and in several of the U.S.A., but most of it is mined in this country, and furnishes the raw material for the manufacture of the various strontium salts.

The metal is soft, of a pale yellow colour, and has to be kept in naphtha, as it readily oxidizes in the air and possesses the property of decomposing water. It is prepared by the electrolysis of the fused chloride, and, like magnesium, it burns brilliantly upon ignition in the air, producing the monoxide SrO.

Strontium Oxides—The monoxide (strontia), like lime, combines with water, with evolution of heat, forming the hydroxide ($Sr(HO)_2$), which is strongly alkaline and more soluble in water than calcium hydroxide. It is used on a large scale in the purification of sugar.

The dioxide (SrO_2) (formed by passing oxygen over the heated monoxide) parts with oxygen upon heating to redness, and is reduced to the monoxide. It is obtained in pearly crystals having the composition $SrO_2,8H_2O$ by adding hydrogen peroxide to a solution of the hydroxide, and is used to some extent in bleaching; it loses the $8H_2O$ when heated at 100° C.

STRONTIUM (*Continued*)—

Strontium Chloride ($SrCl_2 6H_2O$) is a white, crystalline salt, soluble in water and alcohol, and used in pyrotechny for the production of red flames.

Strontium Nitrate ($Sr(NO_3)_2$), obtained by dissolving the oxide or carbonate in dilute nitric acid, is a white, crystalline salt used in the production of red lights and fireworks. It crystallizes with water as $Sr(NO_3)_2 4H_2O$, and when heated with combustible matter, the mixture fires and burns with a characteristic crimson colour.

Strontium Carbonate ($SrCO_3$) is white, practically insoluble in water, and used in the manufacture of pyrotechnics and iridescent glass.

Strontium Sulphate ($SrSO_4$) is white, nearly insoluble in water, and finds increasing use as a paint pigment.

Strontium Saccharate (Saccharate Strontium)—See Sugar, p. 867.

Strontium Chlorate ($Sr(ClO_3)_2$) is a white, crystalline substance, soluble in water, and used in making red-fire, etc.

The bromide, iodide, and salicylate are used in medicine.

STROPHANTHUS—The ripe seeds of *Strophanthus hispidus*, var. *Kombé* (N.O. Apocynacæ), growing in Central Africa, Asia, and the Philippines; used as an arrow poison, also in medicine like digitalis. An active glucosidal principle, strophanthin, is stated to have the formula $C_{23}H_{32}O_6 \frac{1}{2}H_2O$, but is probably a mixture of several substances. (See Jacobs and Hoffmann (*Analyst*, 1928, **53**, 660); W. A. Jacobs (*B.C.A.*, 1930, A, 1413); and Glucosides (Oubain).)

STRYACIN—See Balsams and Cinnamic Alcohol.

STRYCHNINE ($C_{21}H_{22}N_2O_2$)—An exceedingly poisonous white, crystalline, alkaloidal base extracted from *Strychnos nux vomica* (found throughout S. and E. Asia) and St. Ignatius' beans of the order Loganiaceæ, etc.; the alkaloid content being between 2·5 and 3 per cent. of brucine and strychnine. It is chemically related to brucine, melts at 284° C., is soluble in chloroform, and used in medicine for exaggerating spinal reflexes, and as a vermin killer. (See Clemes, Perkin, and Robinson (*J.C.S.*, 1927, p. 1589); Oxford, Perkin, and Robinson (*Ibid.*, p. 2389; 1929, pp. 964-1000); and Leuchs and Wegener (*B.C.A.*, 1930, A, 1455); also Nux Vomica.)

STUCCO—See Calcium Compounds (p. 124).

STUMP TURPENTINE—See Turpentine.

STYRENE (Styrol, Cinnamene, or Phenyl Ethylene) ($C_6H_5CH.CH_2$)—A refractive, oily, yellowish liquid of aromatic odour, with a sp. gr. of 0·912 and b.p. 146° C., obtained from liquid storax (styrax), and used in medicine and perfumery. It is soluble in alcohol and ether, and polymerizes spontaneously upon standing, into a jelly-like mass. (See *Ind. Chem.*, 1931, vii., 424, and Cinnamic Alcohol.)

STYRONE—See Cinnamic Alcohol.

STYROX—See Balsams and Styrene.

SUB—A chemical prefix used to indicate a lower valency; also "less than normal" in respect of basic substances, such as lead suboxide (PbO_2) and the subacetate (basic) acetate of lead ($Pb(C_2H_3O_2)_2,Pb(HO)_2$).

SUB-ATOMICS—A term dealing with the variations presented by atomic materials under varying physical conditions, the result of which investigations are regarded as likely to throw light upon molecular structure. (See report of address by A. Eddington (*The Times*, June 24, 1930); Atoms, Elements, Isotopes, Mass-Spectrograph (p. 538), Neutrons, and Photons.)

SUBERIC ACID ($C_8H_{14}O_4$ or $CO_2H(CH_2)_6CO_2H$)—A member of the oxalic series of acids, originally obtained by the action of nitric acid upon cork, but easily prepared, similarly, from oleic acid or other fatty acids. It is a crystalline body which melts at 140° C., dissolves readily in boiling water, and mixes with fixed oils. When strongly heated, it gives off suffocating vapours.

SUBLIMATION—Sublimation (dry evaporation), particularly under reduced pressure, can be usefully employed for the purification of many substances, such as sulphur, iodine, cantharidin and caffeine, from crude materials, etc. An apparatus for sublimation under reduced pressure is described by T. J. Hedley (*Chem. and Ind.* (*J.S.C.I.*), 1925, p. 752); see also Distillation and Heat.

SUBMERGED COMBUSTION—See Air Lifts and "Hammond" Burner.

"**SUBOX**"—A paint consisting of a suspension of colloidal lead produced electrically. It may be applied when rubbed with linseed oil to iron and other metals, wood, cardboard, and cement: a second coating producing a lustrous lead skin.

SUBSTITUTION PRODUCTS are those which result from the substitution of one element or radical by another in any chemical substance. For example, methane (CH_4) yields four substitution products with chlorine by replacement of respectively 1, 2, 3, and 4 atoms of hydrogen, represented by CH_3Cl, CH_2Cl_2, $CHCl_3$, and CCl_4. Again, nitrobenzene ($C_6H_5NO_2$) is a substitution product obtained from benzene (C_6H_6) by the replacement of 1 atom of hydrogen by the group NO_2. The nature of the mechanism governing substitution is at present the subject of much speculation. (See B. Flürscheim (*Chem. and Ind.*, 1925, **44,** 33); also Radicals and Valencies.)

SUBSTRATE—See Enzymes, p. 313.

SUCCINAMIDE—See Amides.

SUCCINIC ACID ($C_4H_6O_4$ or $CO_2H.(CH_2)_2CO_2H$) is a saturated dibasic acid of the oxalic acid series, and is found amongst the products of the distillation of amber and in certain animal juices, vegetables, and resins. It can be prepared in several ways, including the oxidation of butyric acid and the hydrolysis of ethylene dicyanide. It forms large colourless crystals, is soluble in water, fuses at 186° C., and boils at 235° C., when its vapour is dissociated into succinic anhydride ($C_4H_4O_3$) and water. Its alkaline salts are soluble in water.

SUCCINIMIDE—See Imides.

"SUCHAR"—A vegetable carbon used for sugar refining, etc.

SUCRASE—See Invertase.

SUCROSE—See Sugar.

SUET—See *Analyst*, 1931, **56**, 658 and 778, and Fats.

SUGAR (**Cane Sugar, Beet Sugar, Saccharose, Sucrose**) ($C_{12}H_{22}O_{11}$) is the name used generically with respect to a class of carbohydrates of alcoholic constitution (that is to say, containing OH groups), soluble in water and more or less sweet to the taste; some contain also aldehyde or keto groups. (See Carbohydrates.) "The free sugars are not open-chain compounds, but are cyclic in structure," and evidence of this has been forthcoming. (See *Chem. Soc. Annual Report*, 1929, vol. 26, p. 92.)

Cane sugar is a compound of the two hexose sugars, glucose and fructose, the molecule being regarded as containing eight hydroxyl groups—four in each half of the molecule—and its synthesis has been recently effected by Pictet and Vogel. (See E. F. Armstrong, *Nature*, October 13, 1928.) The manufacture of this sugar is an important industry in the West Indies, the Philippines, Queensland, and Natal, while beet-sugar industry is now carried on in England, roots with a sugar content of 16·5 to 18·4 per cent. being produced at some fourteen factories (at Kelham, Cantley, Ely, Ipswich, and elsewhere), the output being computed at 185,000 tons in 1927-28. The area planted with sugar-cane in India is estimated at about two and a half million acres, and the beet sugar area in England in 1930 at about 380,000 acres. The average yield per acre of topped and washed sugar beet in Great Britain is 8·75 tons and the sugar content 16·7 per cent. on average.

Sugar is a hard, white, crystalline, sweet substance, occurring in the stems or juices of certain grasses and many plants, including the red-beet and sugar-maple, and particularly the sugar-cane (*Saccharum officinarum*) of many cultivated varieties, from which it is produced by pressure between rollers and subsequent purification; one ton of sugar-cane yielding about from 150 to 225 lbs. of sugar. The sugar juice, containing from 83 to 88 per cent. water, as expressed from the canes, is first of all defecated—that is, treated with milk of lime to neutralize acidic ingredients, and boiled to coagulate the albuminous matters contained in the juice—after which the excess of lime is carbonated by the passage of carbon dioxide or removed by precipitation with phosphoric acid. The resulting settled or filtered liquor is evaporated *in vacuo*, and yields upon cooling a mixture of sugar crystals (monoclinic prisms) and syrup, the former being separated from the treacle by centrifugalization. It is refined by dissolving in water, filtration through Kieselgühr, and decolouration by percolation through charcoal, after which it is again concentrated and crystallized. If animal charcoal be used nearly 100 per cent. on the net weight of sugar melted is stated to be required, whereas only 1 per cent. of good vegetable charcoal, such as "suchar," or other good active carbon, is said to suffice.

In an article on the "History of Beet Sugar" (*C.T.J.*, 1925, **76**, 101),

SUGAR (*Continued*)—

Geoffrey Fairrie expresses the view that vegetable carbons cannot do the work of bone charcoal effectually, inasmuch as they do not contain calcium phosphate and other mineral structure essential for the removal of soluble salts from the sugar, and that, on the other hand, by the employment of bone charcoal, white refined sugar of 99·99 per cent. pure sucrose content is readily obtained, both from beet and cane sugar. Much colour requires comparatively much carbon, and where there is much colour, it is probably better to use bone char to remove most, and to finish off with activated carbon.

The molasses (treacle) containing some crystalline sugar still in solution is treated with a solution of strontium hydroxide, which forms a sparingly insoluble combination with it (saccharate strontium, $C_{12}H_{22}O_{11}2SrO$), and after removal by the "Oliver" or other filter, is decomposed while suspended in water, by the action of carbon dioxide, thus forming insoluble strontium carbonate, the sugar meanwhile passing into solution, from which it is recovered by concentration and crystallization. A process has been devised by the G.W. Sugar Refining Co., of Johnstown, Colorado, whereby barium hydroxide can be used in place of strontium hydroxide with certain advantages, and there is a method for converting the resulting barium carbonate into hydroxide, using an electric furnace for effecting part of that purpose.

The molasses finally left is used for making rum, or ordinary alcohol, and the "bagasse" ("bégasse"), or crushed sugar-cane mass, is either subjected to a diffusion process to extract some further proportion of its sugar content or used as fuel. Bagasse may be regarded as a mixture of *a* cellulose, pentosans and lignin. (See Valenzuela and West, *B.C.A.*, 1930, B, 366.) It is also utilized for the manufacture of an artificial building material: after being "chipped," "cooked," and washed, it is sent as pulp to the "beaters," where it is worked until the fibres are of the proper length, after which it is dried and marketed as "celotex," which can be worked like timber, and although lighter than wood, is said to be quite solid and homogeneous. (See E. C. Lathrop, *B.C.A.*, 1930, B, 1126.)

A brief account of the refining of sugar is given by C. M. Keyworth (*Chem. and Ind.*, 1925, **44,** 723), and descriptions of beet sugar manufacture (*Ind. Chem.*, 1926, ii., 21), and by J. Kwantes (*C.T.J.*, 1926, **78,** 463 and 496).

In course of the evaporation of maple sap (from *Acer saccharinum* of N. America and other species) to the syrup stage, a precipitate called "sand," containing from 60 to 83 per cent. of calcium malate, is deposited, and finds use in the preparation of baking-powders, etc.

A flying insect known as the froghopper is particularly destructive to sugar-cane.

Under the most favourable conditions beetroots (*Beta vulgaris*) should yield on average 10 to 12 tons per acre and contain from 14 to 18 per cent. (See *C.T.J.*, 1927, **81,** 182; article on "The English Industry," by C. D. Adams (*J.S.C.I.*, 1928, **47,** 179 T); and *Ind. Chem.*, 1927, iii., 339.)

SUGAR (*Continued*)—

After washing, the beets are cut up by slicers into cossettes and the sugar extracted by hot water, the juice being then subjected to "carbonation"—that is, treating it hot with about 2 per cent. lime and a current of carbon dioxide—and after separating from the calcium carbonate, evaporated to syrup, and finally boiled in a steam-heated jacketed pan until it becomes a mass of crystals in a syrupy mother-liquor. This so-called "massecuite" is then centrifugalized to separate the crystals from the mother-liquor.

In a modified process ("De Vecchis") of making beet sugar the beet slices are desiccated at 90° to 110° C., thus coagulating the albuminoids and breaking the cells. These dried slices can be kept for a long time, and by washing with hot water yield a comparatively pure juice which is purified by lime powder, the excess of which is precipitated as phosphate, the liquid being subsequently filtered, crystallized, and the product centrifugated as usual. This process permits the sugar-making to be carried on at any time during the year, and the residual slices constitute a nutritious feeding-stuff for cattle. For accounts of this process, see C. S. Garrett (*Chem. and Ind.*, 1927, **46**, 1014); G. W. Riley (*Ibid.*, 1036 and 1080); and *Ind. Chem.*, 1927, iii., 545. The desiccation and briquetting of beet pulp is the subject of an article by L. Ternynck (*B.C.A.*, 1929, B, 773).

The so-called "Oxford" desiccation process of beet sugar production is described in the *Ind. Chem.*, 1927, iii., 478, and the report of its development is published by the Clarendon Press, Oxford. References to this process will also be found in the *Ind. Chem.*, 1929, v., 418, and by O. Spengler (*B.C.A.*, 1931, B, 410); see also J. Kwantes on "Chemistry in Beet-Sugar Manufacture" (*Chem. and Ind.*, 1931, **50**, 306).

Mangolds contain from 6·64 to 12·40 per cent. sugar calculated on the dry material, turnips from 10·09 to 14·0 per cent., and carrots from 7·53 to 11·22 per cent. Sugars are also present in Jerusalem artichokes, and their variation is dealt with by S. H. Collins and R. Gill (*J.S.C.I.*, 1926, **45**, 63 T).

Various palms growing in tropical regions, particularly in the Philippine Islands, yield a syrupy sap containing about 15 per cent. sugar, and are employed by natives for making sugar and "toddy," while the banana contains in the ripe state as much as 20 per cent. The manufacture of sugar from Nipa sap (*Hypa fruticans*) is described by M. L. Roxas (*B.C.A.*, 1930, B, 436). The carob which grows in Sicily and other parts of the Mediterranean countries gives a fruit containing from 10 to 34 per cent. saccharose and from 8 to 30 per cent. of reducing sugars. The sugar can be extracted by methyl alcohol.

It is reported that synthetic sugars of the hexose group have been produced by the action of light upon carbon dioxide in presence of water, using a catalyst of nickel or cobalt carbonate. (See Carbohydrates and Photo-catalysis.)

Sugar melts at 160° C. into what is known as barley-sugar, and when further heated to from 170° to 180° C. decomposition occurs,

SUGAR (*Continued*)—

with darkening, loss of water, and formation of so-called "caramel." Subjected to the action of acids, cane sugar is "inverted" by hydrolysis, and whereas it is dextro-rotatory, the invert sugar which is formed is lævo-rotatory and consists of a mixture of fructose and glucose (lævulose and dextrose).

The relative sweetness of various sugars, as determined by the "minimum concentration" method, is given as follows: Cane sugar as 100, lævulose 173·3, dextrose 74·3, maltose 32·5, and lactose 16·0 (Beister (with others), *Analyst*, 1926, **51**, 255).

There is a patented process for obtaining glutamic acid from "schlempe," a by-product of beet molasses (probably bégasse).

The production of sugars (chiefly glucose) from wood and sawdust is referred to under the headings of Glucose and Wood, and that of "corn" sugar under heading of Dextrose. (See W. R. Ormandy (*J.S.C.I.*, 1926, **45**, 267 T), W. R. Ormandy and C. H. Bedford (*C.T.J.*, 1926, **79**, 133 and 137), and W. T. Schreiber (*C.T.J.*, 1930, **86**, 526).) Mr. Bedford gives an account of the production of sugar from cellulose by processes of hydrolysis with hydrochloric acid (the "Rheinan," "Prodor," and "Classen" methods, the last-named of which employs the use of certain catalysts to promote the action).

Sugar in its several forms is a valuable food, and is largely used as a sweetener, in the preparation of syrups, preserves, and jams, and for the manufacture of alcohol, etc. The total world output of cane sugar is estimated at about 30 million tons, of which about one-third is beet sugar. It is marketed in many forms, such as "loaf," "cube," "lump," "granular," "icing," etc. The so-called "soft" sugars contain a proportion of molasses, also of invert sugar.

Other references: The precipitation of calcium sulphite resulting from the "sulphitation" process of sugar refining practice, by R. G. W. Farnell (*J.S.C.I.*, 1925, **44**, 530 T), and the precipitation of calcium phosphate in connection with the industry by the same writer (*J.S.C.I.*, 1926, **45**, 343 T); Report by B. J. Owen (H.M. Stationery Office, 1927); the "Disposal of Effluents from Beet-Sugar Factories" as the subject of study by the Water Pollution Research Board, 1929, and 1930 (H.M. Stationery Office), and by A. J. V. Underwood (*Ind. Chem.*, 1927, iii., 260; 1928, iv., 90), and E. Nolte (*B.C.A.*, 1932, B, 81); "Beet Sugar Manufacture," by J. Kwantes (*Chem. and Ind.* 1926, **45**, 638); "The Sugar Industry in some of its Chemical Aspects," by C. A. Browne (*Chem. and Ind.*, 1927, **46**, 26); "Structural Formulæ of Sugars," by W. N. Haworth (*Chem. and Ind.*, 1929, **48**, 240); "Degradations in the Sugar Group," by V. Deulofew (*J.C.S.*, 1930, p. 2602); Milne, Jones, and Willcox on "Sugar Beet" (*J.S.C.I.*, 1931, **50**, 155 T); "Classification of Sugars," by J. W. Maltby (*J.C.S.*, 1923, **123**, 1404; 1926, p. 1629; and 1929, p. 2769); "Structure of Carbohydrates and their Optical Rotary Power," by W. N. Haworth (and associates) (*J.C.S.*, 1930, pp. 2615-2663); "The World's Sugar Industry," by Lewis Eynon (Lecture, Instit. of Chem.); *The Constitution of Sugars*, by W. N. Haworth (E. Arnold and Co.); *A. Handbook for*

SUGAR (*Continued*)—

Cane-Sugar Manufacturers and their Chemists, by G. L. Spencer (Chapman and Hall, Ltd.); see also Caramel, Carbohydrates, Fermentations, Glucose, Malt, Sorghum, Waxes (Sugar-Cane), and Yeasts.

SUGAR-CANE WAX—See Waxes.

"SUGAR OF LEAD"—See Lead (Acetate).

SUGAR OF MILK—See Lactose.

SUGAR-SOAP—An alkaline, readily soluble soap preparation used by painters for washing down before applying fresh coats of paint or varnish. (See *C.T.J.*, 1930, **86**, 389.)

SUINT—See Wool.

"SULFOPONE"—See Paints.

SULPHATES—See "Sulphates in Industry," by C. H. Butcher (*C.T.J.*, 1930, **87**, 633, and 1931, **88**, 51 and 125), and p. 880.

SULPHIDES—See p. 135 and Sulphur Compounds.

SULPHIDES (Organic)—The substances known as mercaptans have the nature of sulphides; ordinary mercaptan is ethyl hydrosulphide (C_2H_5HS) and ethyl sulphide is $(C_2H_5)_2S$. The alkali disulphides can be used in the making of organic disulphides, and the organic polysulphides resemble the polysulphides of the alkali metals very closely.

SULPHION—This term is sometimes used to indicate the bivalent ion S'' as derived from hydrogen sulphide, and at others to indicate the SO_4 radical or ion produced, as is thought, in the electrolysis of a solution of copper sulphate.

SULPHITE LIQUOR AND PULP—See Paper.

SULPHITES—See Sulphur Compounds; Sodium Sulphites; and paper by "Omega" (*C.T.J.*, 1926, **79**, 389).

SULPHO—A prefix indicative of the presence of either the $>SO_3$ group or the group $—SO_2—OH$.

SULPHO-CARBOLATES are compounds prepared from phenol-sulphonic acid ($C_6H_5SO_3H$). The zinc salt is used medicinally.

SULPHOCYANIC ACID, otherwise known as thiocyanic acid (CNSH), is the sulphur analogue of cyanic acid (CNOH).

SULPHOCYANIDES (Sulphocyanates)—See Thiocyanides.

SULPHONAL (Sulphone Methane) ($C_7H_{16}S_2O_4$ or $(CH_3)_2 : C(SO_2.C_2H_5)_2$)—A colourless crystalline substance, prepared from acetone and mercaptan by action of hydrochloric acid, and used as a soporific and hypnotic. It melts at 125·5° C. and is soluble in alcohol.

SULPHONATED OILS—A number of these products are made and used commercially, "Turkey-red oil" being made as described under that heading by the action of strong sulphuric acid on castor oil. Other oils used include arachis, cotton-seed, cod and other fish oils, maize (corn) and neatsfoot oils. (See M. Briscoe (*Ind. Chem.*, 1932, viii., 67).)

SULPHONATED OILS (*Continued*)—

Commercial sulphonated castor oil varies in density from 1·022 to 1·025, and is miscible with water.

These oils, of which there are various types suitable for many applications, are used in branches of the leather trade to give softness and pliability to the articles; also in the preparation of cotton fibre; impregnating the warp threads of artificial silk; for greasing wool, etc.; as mordants for certain dyes; as finishing oils for cotton, silk, linen, and leather; also in paint and varnish-making. (See Turkey-red Oils; also *C.T.J.*, 1925, **76**, 163.)

SULPHONATION—Treatment of organic compounds with sulphuric acid, whereby sulphonic acids are produced, the products containing the group $.SO_2.OH$. Thus benzene (C_6H_6), treated with fuming sulphuric acids, yields benzene sulphonic acid ($C_6H_5.SO_2.OH$) by substitution of the sulpho group for hydrogen: $C_6H_6 + H_2SO_4 = C_6H_6SO_3 + H_2O$.

Sulphonation can be carried out not only by the use of liquid acid, but also in the vapour phase with, it is stated, a saving of acid. (See Naphthalene-Sulphonic Acid (p. 600) and Sulphonated Oils.)

SULPHONIC ACIDS (Aliphatic and Aromatic)—Organic compounds containing the monovalent sulpho (sulphonic) group, $SO_2.OH$ or $-SO_3H$, in association with alkyl or aryl residues. (See Sulphonation.)

SULPHUR (S) (**Brimstone**) **and its Compounds**—Atomic weight, 32·06; said to have 3 isotopes. Large quantities of sulphur are found naturally in Japan, Spain, and the U.S.A., also in volcanic districts, including Italy, Sicily, Chile, and Iceland, and there are considerable beds of it in the Löcken mines south-east of Tronhjem (in Scandinavia), Transylvania, China, India, Japan, Texas, and California. The Italian production of sulphur in 1928-29 was 323,000 metric tons, that of Sicily about 247,000 tons, while that of the U.S.A.—about 2,400,000 long tons—constitutes some four-fifths of the world output, 99 per cent. of which is produced in Texas, the production in that state amounting to 1,071,100 short tons in 1930. Some statistics of the world's sulphur position, including pyrites, are summarized in the *Ind. Chem.*, 1930, vi., 315.

The Sicilian method of extraction is by a process in which the sulphur rock is ignited, the heat thus generated being used to melt the surrounding parts, attended with an approximate loss of 15 per cent. of the total sulphur, but a project is in hand to electrify all operations in future.

In Texas, the comparatively pure sulphur is first of all melted underground by hot water pumped into the deposit, and then forced up in the liquid state.

Sulphur is also found naturally in various combinations as sulphides, of which the best known are *galena*, or lead sulphide (PbS); *zinc blende*, or zinc sulphide (ZnS); *iron pyrites*, or iron sulphide (FeS_2); *copper pyrites* ($Cu_2Fe_2S_4$), and *Cinnabar* (mercury sulphide, HgS). (See Pyrites.)

SULPHUR (*Continued*)—

The mineral *gypsum*, or calcium sulphate ($CaSO_4.2H_2O$), contains sulphur in combination with calcium and oxygen and water; whilst *heavy spar* also contains sulphur in the form of barium sulphate ($BaSO_4$).

Sulphur, as obtained from its crude natural form, is purified by melting and vaporization (sublimation). As a constituent of pyrites, it is utilized in the manufacture of sulphuric acid, and it can be recovered from the sulphurized oxide of iron (spent oxide) resulting from the process used in gasworks for freeing the gas from hydrogen sulphide. This is done either by burning off the sulphur into the form of sulphur dioxide or oxidation of the sulphurized mass, thereby revivifying the ferric oxide, $2FeS + 3O + 3H_2O = 2Fe(OH)_3 + 2S$, the sulphur thus set free being subsequently distilled or burnt off. (See Sulphur Recovery, p. 882.)

A German war-time process for making sulphur was based upon the reaction that takes place between calcium sulphide and magnesium chloride when boiled together; the hydrogen sulphide (H_2S) thus liberated being burned in air under such conditions that only the hydrogen is consumed and the sulphur is deposited. The calcium sulphide primarily employed and converted into sulphate can be reconverted into sulphide by heating it together with coal in a revolving furnace at 1,100° C.

When hydrogen sulphide (H_2S) and sulphur dioxide (SO_2) gases are mixed together, sulphur is deposited according to the equation $H_2S + SO_2 = 2H_2O + 2S$. (See Rubber Vulcanization, p. 773.)

Sulphur affords one of the most interesting instances of substances which can assume a number of varying or so-called allotropic forms. In its ordinary form, it is a yellow crystalline body of octahedral formation, but by melting it under certain conditions it can be obtained in the form of prismatic needles of transparent character which melt at 119·2° C., and upon exposure to the air gradually lose their transparency, crumble up, and assume once more the form of octahedra. The ordinary rhombic form has a density of 2·07, and melts at about 112·8° C. to a yellow, limpid liquid; but if the temperature be allowed to rise to 180° C., it becomes quite viscid and darkens very much in colour. If the heat be still further raised to 260° C., it becomes less viscid, but not so fluid as when first melted. If, when in the viscous state, it be allowed to cool suddenly (as by pouring it into cold water), it solidifies into a soft mass, which can be drawn out into elastic threads, having a sp. gr. of 1·96, and is not soluble in carbon disulphide, whereas the natural crystalline form has a sp. gr. of 2·07 and is very soluble. This form can be again transformed into the original by heating it to 100° C., when it suddenly returns to the brittle condition with an evolution of heat; a change which also takes place if it is kept for a short time. Precipitated sulphur is rapidly and completely soluble in carbon disulphide and also slowly so in methylated spirit and petroleum spirit, whereas the sublimed substance is only soluble to about 83 per cent. in each of these solvents (D. Henville, *Analyst*, 1930, **55**, 385). The

SULPHUR (*Continued*)—

experiments of Hammick and Zvegintzov would make it appear that insoluble sulphur is not present as such in liquid sulphur, but makes its appearance when the liquid solidifies (*J.C.S.*, 1930, p. 277).

Even in the gaseous form it is known to exist in several conditions or polymeric states dependent, as surmised, upon the number of atoms in the molecule.

When melted sulphur is cooled until a solid crust covers the surface and the remaining liquid content poured off, the sides of the vessel will be found covered with long, needle-shaped (monoclinic) crystals having a density of 1·96 and m.p. 119·2° C.

Crystals deposited from a solution of sulphur in carbon disulphide are of the rhombic character, while those deposited from alcohol and chloroform are of the monoclinic description. There is said to be a colourless variety of rhombic character.

When sulphur is distilled in small quantities and the vapour allowed to condense in a vessel not artificially cooled, it takes the form of red oily drops which remain fluid for some hours, but afterwards pass into the solid condition.

Between 117° and 157° C. the sulphur molecule appears to be S_6, and S_{18} between 180° and 445° C.

It is stated that sulphur can be activated by the silent electric discharge, and in this form shows an increased activity towards hydrogen and carbon monoxide (Schwarz and Schenk, *B.C.A.*, 1929, A, 1151).

It may be sublimed—that is to say, it can be vapourized by heat, and the vapour can then be condensed into the solid state as so-called "flowers of sulphur" consisting of minute crystals. Its b.p. is 444·6° C.

In precipitated form, as obtained, for example, from polysulphides in solution, it is known as "lac sulphur," and this form is used by agriculturists for depositing on plants after spraying them with lime-sulphur solution, for fungicidal application.

So-called "Colloidal Sulphur" is the subject of a paper by Bassett and Durrant (*J.C.S.*, 1931, p. 2919) and of a letter by Perrin and Strevens (*Ind. Chem.*, 1932, viii., 16).

Sulphur is marketed in the forms of crystals, "roll," "precipitated," and "sublimed" (flowers).

Sulphur exercises a valuable toxic action as a fungicide; for example, flowers of sulphur applied in paste form to hot-water pipes in greenhouses will keep in check diseases of the mildew type on plants kept in the houses, its activity being largely dependent upon its fineness of division. About 10,000 tons of powdered sulphur are stated to be used annually in Italy for treating grape-vines, with satisfactory results.

At one time sulphur was largely used in the making of matches, but these have since been superseded by other sorts. It is used in the manufacture of gunpowder and sulphuric acid, also in the sulphite process of wood digestion (in connection with cellulose and paper-making), preparation of ultramarine, vulcanizing processes, in pharmacy (in compounding so-called milk of sulphur and other medicaments), as a fertilizer, and for fumigating beer casks and infected rooms.

SULPHUR *(Continued)*—

A slight sulphur dusting is alleged to obviate the spontaneous inflammation of oily wiping rags and other materials. It is also used in admixture with other substances for the production of almost non-inflammable moulded objects of high plasticity. For example, a mixture of 60 parts sand and 40 parts sulphur forms a good substitute for cement, and can be used for setting bricks in acid towers or in the construction of acid-proof tanks, the tensile strength being almost 400 lbs. per square inch. Concrete articles dipped in molten sulphur will take up from 14 to 16 lbs. per cubic foot, and the normal strength is stated to be thus increased ten-fold. Dense sandstone will take up some 84 per cent. of its own volume when similarly treated, and wood can be usefully preserved by sulphur impregnation. (See W. H. Kobbé, *C.T.J.*, 1924, **75**, 520.) Large proportions of sulphur can also be used in conjunction with pitch or bitumen as good binding agents in the construction of chemical plant.

Appreciable quantities of sulphur compounds are evolved from flowers of sulphur in presence of air at temperatures from 17° C. and upwards (Stevenson and Bridge, *Analyst*, 1929, **54**, 591).

An American paper, by C. A. Newhall, on the "Manufacture and Uses of Refined Sulphur," is reproduced in the *C.T.J.*, 1924, **75**, 181. (See also W. H. Kobbé on "New Uses for Sulphur," etc. (*Ibid.*, 701).)

Sulphur Oxides—Sulphur burns in the air with a blue flame and gives rise to the production of sulphur dioxide (SO_2), a gas of pungent, irritating nature which may be condensed and liquefied, or a solution of it in water can be prepared. The liquefied gas is used to some extent as a refrigerating agent, also in preservation of foodstuffs and preparation of dyes. In all three forms it is used for disinfecting purposes and for bleaching straw, silk, wool, and sponge. (See Fumigation.)

According to B. Neumann (*B.C.A.*, 1927, B, 106) sulphur dioxide is produced to the extent of 90 per cent. yield by heating a mixture of blast furnace slag and gypsum at 1,400° C. for fifteen minutes. If calcium sulphide be present in the slag, the reaction is represented as follows: $CaS + 3CaSO_4 = 4CaO + 4SO_2$, but the presence of calcium sulphide is not essential at that temperature.

As employed for use in the manufacture of sulphuric acid, the gas is produced using burners of various types for combustion of the sulphur or the roasting of pyrites. Among these may be mentioned the "Wedge Sulphur Furnace," the "Glensfalls Rotary Sulphur Burner" (see *Ind. Chem.*, 1925, i., 341-343), and a new type, the "Freeman Burner," described in the *C.T.J.*, 1930, **86**, 501, and 1931, **88**, 1. A description of various burners used for the combustion of sulphur-containing materials is given by P. Parish in an article in which also will be found an analysis of "spent oxide"—that is, the iron oxide which has been used in purifying coal gas (*J.S.C.I.*, 1925, **44**, 307 T, and some of the following numbers). (See Pyrites.)

A new American plant for making anhydrous SO_2 is described by Hitchcock and Scribner (*Ind. Eng. Chem.*, July, 1931).

SULPHUR (*Continued*)—

Kingzett's sulphur candles (Sanitas Company's), for fumigating purposes, are provided with special wicks, so that the burning of the sulphur is completely ensured, and (as made in one variety) meanwhile causes the simultaneous evaporation of water, which materially assists the sterilizing effects of the generated sulphur dioxide. (See Fumigation.)

Of the oxides of sulphur, the two most important are the gaseous dioxide (SO_2) (which boils at $-10{\cdot}1°$ C. under atmospheric pressure, and is soluble in water to the extent of 79·789 volumes in 1 volume at 0° C.) and the trioxide (SO_3). Below 7° C. a saturated solution of sulphur dioxide is stated to be supersaturated with respect to the crystalline hydrate SO_27H_2O.

The trioxide is produced when a mixture of SO_2 and oxygen are passed over strongly heated spongy platinum or other catalyst (such as ferric oxide with or without a little cupric oxide or some vanadian compound such as silicate), which effects their combination into the form of white silky needles when condensed in a cooled receiver. Platinized silica gels, under certain conditions, are stated to be more effective than platinized asbestos, while a satisfactory vanadium catalyst is immune to the usual poisons. (See "A New Vanadium-process Contact Plant" (*C.T.J.*, 1931, **88**, 3).) It is a volatile body which fumes in the air, melts at 16·8° C., boils at 44·52° C., and combines eagerly with water, forming sulphuric acid ($SO_3 + H_2O = H_2SO_4$). It is alleged that there are really four modifications of sulphur trioxide having different vapour pressures.

There appears to be another oxide of the composition S_2O_3, which dissolves in oleum forming a deep blue solution.

The "Cambridge Electrical SO_2 Recorder" is referred to under the heading of Recorders.

The acids formed from the oxides include hyposulphurous, sulphurous, sulphuric, and thiosulphuric acids. Other combinations are known as dithionic acid ($H_2S_2O_6$), trithionic acid ($H_2S_3O_6$), tetrathionic acid ($H_2S_4O_6$), and pentathionic acid ($H_2S_5O_6$), and there are corresponding salts. The pentathionic acid is formed by passing hydrogen sulphide into a strong aqueous solution of sulphur dioxide, or by the action of sulphur dioxide on sulphur in aqueous suspension.

Hyposulphurous (**Hydrosulphurous**) **Acid** ($H_2S_2O_4$) can be made from sulphurous acid by reduction with zinc, when the hydrogen generated in a nascent state is not evolved, but combines as expressed in the equation ($2H_2SO_3 + H_2 = H_2S_2O_4 + 2H_2O$). In solution, this unstable acid exhibits a yellowish colour and considerable bleaching properties.

Sulphurous Acid (H_2SO_3) is known only in solution and is somewhat unstable, but less so than the hyposulphurous acid. It has a strong odour of sulphur dioxide, and gradually undergoes decomposition by atmospheric oxygen. Being dibasic in character, it forms two series of salts, which are represented by potassium hydrogen sulphite, or acid potassium sulphite ($KHSO_3$), and potassium sulphite (K_2SO_3).

SULPHUR (*Continued*)—

The various alkaline sulphites are crystalline compounds, obtained by the interaction of sulphur dioxide and an alkali in the presence of water; a hot aqueous solution of the alkali carbonate being treated with the SO_2 gas until the desired salt is completely formed in solution of the requisite strength, to crystallize out on cooling. The calcium salts are similarly made, using calcium hydroxide ($Ca(OH)_2$) or the carbonate ($CaCO_3$).

Thiosulphuric Acid ($H_2S_2O_3$) is not known in the free state, being of very unstable character, but it forms well-defined salts, obtained by digesting flowers of sulphur in solutions of sulphites. Sodium thiosulphate ($Na_2S_2O_4,5H_2O$) (incorrectly described as sodium *hyposulphite,* and commonly known as "hypo") can be prepared by the action of sulphur dioxide on sodium sulphide in solution, and is the most important. Previous to the Great War, most of this salt was made from alkali waste by aerial oxidation of the calcium sulphide contained therein into calcium thiosulphate, followed by extraction and treatment of the extract with sodium carbonate or sodium sulphate, thus precipitating insoluble calcium carbonate or sulphate, and leaving sodium thiosulphate in solution, from which it was crystallized out. It is also made by interaction of zinc hyposulphite and sodium carbonate. A newer process consists in agitating sodium sulphite and sulphur in admixture, the thiosulphate being thus produced in solution ($Na_2SO_3 + S = Na_2S_2O_3$), and there is a further development, in which sodium carbonate, sulphur dioxide, and sulphur react in presence of water to form the compound in question. It is a crystalline body very soluble in water, and largely used in photography in the process known as "fixing"; also as an "antichlor." Potassium thiosulphate can be prepared by the reaction $2KSH + 4KHSO_3 = 3K_2S_2O_3 + 3H_2O$. (See Bassett and Durant on "Inter-relationships of the Sulphur Acids" (*J.C.S.*, 1927, p. 1401).)

Sulphuric Acid (Oil of Vitriol) (H_2SO_4) is one of the most important sulphur compounds, and is manufactured from sulphur dioxide—as produced from the roasting of pyrites (the temperature of combustion ranging about 1,216° C.), or burning sulphur in air—by oxidation of the sulphur dioxide (SO_2) vapour in contact with moisture (water vapour) and using the agency of gaseous nitric peroxide, thus: $2SO_2 + 2NO_2 + 2H_2O = 2H_2SO_4 + 2NO$, the sulphuric acid thus produced being absorbed or dissolved in water. In other words, through the agency of the nitric peroxide the SO_2 is made to take up an extra atom of oxygen, and this, in combination with water, furnishes sulphuric acid ($SO_2 + O + H_2O = H_2SO_4$).

The nitric peroxide is obtained from nitric acid, which in turn is produced by the action of strong sulphuric acid (H_2SO_4) upon sodium nitrate ($NaNO_3$): $2NaNO_3 + H_2SO_4 = Na_2SO_4 + 2HNO_3$ (see p. 619).

In this process, the nitric peroxide (NO_2) gives up some of its oxygen,

SULPHUR (*Continued*)—

being reduced to nitric oxide (NO), which becomes peroxidized again by the air, regenerating the NO_2, to serve anew.

An alternative method of supplying nitrogen oxides to sulphuric acid chambers (or mechanically constructed substitutes therefor), and now commonly adopted, consists in the use of a so-called converter, by means of which ammonia (using a gaseous mixture containing 10 per cent. ammonia) is converted into nitrogen oxides. (See Nitrogen Fixation, p. 620.)

Arsenic and selenium are recovered from the flues of the pyrites burners when these are employed for generating the sulphur dioxide.

In the practical manufacture of sulphuric acid, the gaseous sulphur dioxide mixed with air can be "nitrated" by passing the mixture up what is known as a "Glover tower," in which it encounters a stream of nitric acid or nitrated sulphuric acid slowly flowing over flints or other serviceable materials (such as tower-rings, brick, or coke), after which it is passed into leaden condensing chambers of varying construction, into which steam or water (in the form of fine spray) enters, and in which the sulphuric acid is condensed. The water spray system for sulphuric acid chambers finds special reference in a Report of the Chief Alkali Inspector (*Chem. and Ind.*, 1929, **48**, 789). The current of air carrying nitrous gases is made to pass up what is known as the "Gay Lussac tower," where it encounters a stream of sulphuric acid trickling over coke packed in the tower, with the result that the nitrous gases are absorbed, and the acid so charged is used over again in the "Glover tower." (See Scrubbing.)

Sometimes two Gay Lussac towers are used, the second one being fed with water instead of sulphuric acid, a modification which is stated to be attended with advantage in the saving of acid.

The "Stantial Divided Glover tower" is an improved design which effects nitric acid concentration on an economical basis. (See *C.T.J.*, 1925, **76**, 692.)

The "Schmiedel" box is part of a sulphuric acid plant that functions in the same way as a "Glover tower," and accounts of its use are given in papers by H. J. Bush (*C.T.J.*, 1927, **80**, 305) and Arthur Grounds (*Ind. Chem.*, 1927, iii., 208, and 1928, iv., 155).

The chambers in which the acid is made are of various forms, including the ordinary rectangular lead-lined chamber, the "Moritz" cylindrical, the so-called "Void" chamber, and the Mills-Packard water-cooled chambers. Some details about the last-named plant will be found (*Ind. Chem.*, 1927, iii., 148); "Points in Chamber Plant Operations," by A. T. Newell, are summarized (*C.T.J.*, 1927, **81**, 480); and "The Trend of Development in the Chamber Process" (H. Watson, *Ibid.*, 1930, **86**, 447).

In the so-called "packed cell" process the gases are forced by a fan into the "Glover tower," and thence into a series of five cells lead-sheathed, and packed with acid-resisting bricks, up and down alternately, and from these cells the acid passes to the coolers, the "Gay Lussac tower" being utilized in the ordinary way. These cells

SULPHUR (*Continued*)—

are used to save space, and part cost involved by the use of the old-fashioned large lead-lined chambers.

In another patented process (E.P. 231,921; 11.12.23) the burner gases are forced in one direction through sectional flues which replace the "Glover tower" chambers and "Gay Lussac tower" of the ordinary plant, while sulphuric acid flows by gravity in the reverse direction through a series of pools within the flues.

The "Opl tower" system of producing sulphuric acid is very like the "packed cell" method, while in another intensive system of manufacture what is known as the "Duron tower" is employed.

The acid as ordinarily prepared is of about 70 per cent. strength, and is concentrated by evaporation or by passage down a tower in the form of fine spray, in which it encounters a current of hot producer gas which carries off the water, the concentrated acid being collected at the base. The concentration of sulphuric acid for industrial purposes is also effected in heated vessels of lead, glass retorts, platinum stills, cast-iron pots, or by so-called cascade concentrators according to requirements. Certain commercial varieties of sulphuric acid are marketed in strengths of 140° and 160° Tw. and 144° Tw. arsenic free. J. P. Rogers has prepared an improved dilution table showing the amounts of acid and water at 15° C. which, mixed together, will give a diluted solution of the required sp. gr. and volume (*Ind. Chem.*, 1929, v., 223). "Economics in Vitriol Making" is the subject of articles by T. L. Bailey (*C.T.J.*, 1926, **78**, 722); its concentration in a plant of fused silica (*Ind. Chem.*, 1931, vii., 483); and "The Manufacture of Sulphuric Acid, Chamber-Process," is dealt with in Wilfrid Wyld's work (Gurney and Jackson, London). (See also Cottrell Precipitating Plant.)

Another process of manufacture resulting from war necessity consists of calcining at from 1,100° to 1,200° C., a mixture of finely powdered gypsum and coal in definite proportions, thus yielding a kind of cement and sulphuric acid or oleum at choice. (See H. Molitor (*B.C.A.*, 1927, B, 520); *Ind. Chem.*, 1929, v., 491 (in which article a flow sheet of the anhydrite process is given); and *C.T.J.*, 1930, **86,** 569, for an article on the economics of this process by A. J. Caddick. The generation of the sulphur dioxide is promoted by the use of about 4 per cent. ferric hydroxide. This process, as modified by the use of aluminous additives, such as clay, slate, or argillite, etc., and used by the Bayer Company in Germany, is referred to in an article in the *C.T.J.*, 1926, **79,** 3. (See also Ammonium Sulphate, p. 613.)

The chief feature of what is known as the "Petersen" sulphuric acid process is that the nitrogen oxides are not employed in gaseous form, but in sulphuric acid solution.

Sulphuric acid is also produced as a by-product in the roasting of copper and zinc ores, and from the gaseous effluents from power stations, the complete combustion of the coal used resulting in the production of the acid from the sulphur contained in the fuel. If the acid so produced can be washed out of the gases on an economical

SULPHUR (*Continued*)—

basis, the quantity so obtainable will materially affect its production by other processes. Its removal by water spraying is dealt with by Ardern and Wheeler (*C.T.J.*, 1929, **85**, 580). (See also S. L. Pierce, *Ibid.*, 1930, **87**, 378 and 537.)

A variation known as the "Martin" process of manufacture is described by C. Millberg (*C.T.J.*, 1926, **79**, 538), and consists mainly of so regulating the temperatures that they approach the ideal for the most rapid oxidation of the sulphur dioxide and for the reoxidation of the nitric oxide. Some recent American developments in the manufacture are described by S. F. Spangler (*Ind. Eng. Chem.*, May, 1929, and reproduced in the *C.T.J.*, 1929, **84**, 535).

The dearsenication of sulphuric acid is referred to under the heading of Dearsenicator.

It is estimated that half of the world's production of sulphuric acid is employed in making superphosphate.

Fuming Sulphuric Acid ("Oleum") was originally prepared at Nordhausen in Saxony by the distillation of ferrous sulphate, the gas generated in this way being condensed in ordinary sulphuric acid, so that it really consisted of a mixture of sulphur trioxide (SO_3) and sulphuric acid (H_2SO_4). The fuming acid can also be produced by the dry distillation of anhydrous sodium bisulphate. It is now made on a rapidly increasing scale by the catalytic or contact process, as referred to already under Sulphur Oxides (p. 875).

Instead of using a mixture of sulphur dioxide and oxygen, ordinary sulphuric acid can be split up by great heat into water, sulphur dioxide, and oxygen: the water is removed and the remaining fixed gases are (in the Mannheim process) passed over ferric oxide (which effects the combination to the extent of about 60 per cent.), and then over some suitable material, such as asbestos coated with finely divided platinum, or vanadium silicate maintained at a temperature lower than that used to break up the original acid, in order to complete the combination into the trioxide (SO_3), which can then be condensed as such or in sulphuric acid (as made by the ordinary process) in order to concentrate it. The platinum when used is deposited on the asbestos, pumice-stone, or other carrier, by soaking it in a solution of platinum and ammonium chlorides and heating to dull redness. In the "Grillo" plant, calcined magnesium sulphate in coarse grains is used as the platinum carrier.

In a modification of the Mannheim process (the Bastard-Mannheim plant), platinum catalyst is not employed at all, the sulphur dioxide gas from the pyrites burners being passed up a shaft packed with granules of ferric oxide only (actually small lumps screened from the pyrites burners), and in this way from 30 to 40 per cent. of the gas is converted into trioxide, which is absorbed in sulphuric acid of suitable strength to produce acid of 90 to 100 per cent. H_2SO_4 or oleum up to 20 per cent. SO_3 strength. As alternatives to the use of platinum, vanadium and its compounds have in recent years supplanted it as cheaper and effective catalytic agents. (See *C.T.J.*, 1929, **84**, 229, and an

SULPHUR (*Continued*)—

account of the "Selden" contact process in which vanadium catalysts are used (*Ind. Chem.*, 1929, v., 370).)

An account of oleum manufacture, as carried out by the Nobel's Explosives Company at their Ardeer factory, is given in the *Ind. Chem.*, 1926, ii., 525.

The contact process of manufacture is the subject of a paper by W. H. De Blois (*Chem. and Ind.*, 1927, **46**, 257), and of a work by F. D. Miles, being vol. iv. of Lunge's *Acids and Alkalies* (Gurney and Co, London, 1925).

Twenty per cent. SO_3 oleum is liquid, but with a concentration of 40 per cent. it becomes a crystalline solid, while at 60 per cent. it again becomes liquid, reverting once more to the solid state when the SO_3 reaches 80 per cent. At 100 per cent. H_2SO_4 has a sp. gr. at 15° C. of 1·984.

Much of the oleum produced in this country during the Great War was obtained by the concentration of the ordinary acid, the requisite quantity of water being evaporated therefrom in towers and cascade evaporators constructed of acid-resisting ferro-silicon or silica basins. A fuming sulphuric acid of any desired strength can be prepared by mixing concentrated sulphuric acid and fuming sulphuric acid of a given strength in the proper proportions.

In the pure state, sulphuric acid is a heavy, colourless, oily body of very corrosive properties, having a great affinity for water, and reacting with the oxides and carbonates much in the same way as hydrochloric and nitric acid, thus forming the corresponding sulphates. It is stated to retain its drying capacity—absorptive power for water—until it is completely converted into the di-hydrate (84·48 per cent. H_2SO_4). The annual production of the various forms of this acid in the United Kingdom is reported at one time to have exceeded 4,000,000 tons; in pre-war time it exceeded 1,080,000 tons, but it declined to 848,000 tons in 1925. Of this quantity 88½ per cent. before the Great War was made from pyrites, but in 1925 this figure had fallen to 47½ per cent., the percentage from spent oxide being 24 per cent., from brimstone 24 per cent., and from zinc and copper furnaces about 5½ per cent. Its utilization in making fertilizers is on a declining scale, but it still finds use in a great number of industrial applications, such as the manufacture of accumulators, alums, celluloid, explosives, dyes, washing soda, glucose, ammonium sulphate, superphosphate, sugar-refining, and in dilute form (1 : 10 or 12) as an insecticide and weed-killer, etc.

Sulphates—In addition to the ordinary sulphuric acid (SO_3,H_2O) there are several definite combinations of SO_3 with water represented by the formulæ $2SO_3,H_2O$, H_2SO_4,H_2O, $H_2SO_4,2H_2O$, and $H_2SO_4,4H_2O$, so that in addition to the sulphates corresponding to H_2SO_4, such as the potassium salt (K_2SO_4), the barium salt ($BaSO_4$) and potassium hydrogen sulphate ($KHSO_4$), there are known compounds corresponding to some of the other molecular combinations. (See Persulphates.)

SULPHUR (*Continued*)—

Hydrogen Sulphide (Sulphuretted Hydrogen, H_2S) is an offensive-smelling gas found in nature in volcanic areas; is contained in many mineral waters (such as Harrogate), which are used medicinally, and can be prepared in liquefied form.

It is produced by the direct interaction of hydrogen and heated sulphur, and can be prepared by the action of dilute hydrochloric acid (or sulphuric acid) upon ferrous sulphide. (See Gas Generators.)

$$FeS + 2HCl = FeCl_2 + H_2S.$$

A convenient laboratory method of making the gas is by heating together sulphur and paraffin wax in equimolecular proportions, mixed with finely divided asbestos, thus yielding a copious stream of the pure gas.

An improved form of generator is described by H. C. Denham and J. Packer (*J.C.S.*, 1926, p. 1344).

In liquefied form it boils at $-61 \cdot 8°$ C. under atmospheric pressure, while in gaseous form it is colourless, poisonous, soluble in water (to the extent of 4·37 volumes in 1 volume water at 0° C.), and burns when ignited, producing sulphur dioxide and water:

$$2H_2S = 3O_2 = 2SO_2 + 2H_2O.$$

It forms sulphides by interaction with a number of metals, oxides, and metallic salts, and tarnishes many metals by direct interaction.

The sulphides of the metals of the alkalies and alkaline earth groups are more or less soluble in water, but the others are insoluble.

Hydrogen Persulphide (H_2S_2), prepared by the action of hydrochloric acid upon calcium or sodium disulphide at a low temperature, is a yellow heavy oily body, of sp. gr. 1·376, capable of dissolving sulphur, and can be used for the vulcanization of rubber in the cold.

Sulphur Chlorides—Sulphur and chlorine by interaction yield several interesting bodies—namely, a monochloride S_2Cl_2 and others, including the dichloride SCl_2 and the tetrachloride SCl_4, which is known as an almost white solid. The first is formed by passing a stream of dry chlorine gas over molten sulphur, when it distils over as an amber-coloured volatile liquid of unpleasant irritating odour. The dichloride is produced by the same process conducted at a temperature not above 0°, and is also a dark reddish liquid of much less stable character. Both have the property of dissolving sulphur with avidity, and are used for vulcanizing rubber, making rubber substitutes and cements, etc. (See Lowry (with others) (*J.C.S.*, 1927, Trans., p. 746, and 1930, p. 1005; *Ibid.*, 1929, p. 1421; 1930, p. 782; 1931, p. 323; *Chem. and Ind.*, 1930, **49**, 183-184).) For a summary of Lowry's papers, see *B.C.A.*, 1930, A, 1389.

Sulphur Oxychlorides number four compounds having the formulæ $SOCl_2$ (thionyl chloride), SO_2Cl_2, $So_2Cl(HO)$, and $S_2O_5Cl_2$. The second

SULPHUR (*Continued*)—

of these compounds is known as sulphuryl chloride, the third one as chloro-sulphonic acid, and the last as disulphuryl chloride.

Sulphur Recovery—Among other processes devised for the recovery of sulphur from waste gases containing sulphur dioxide, may be mentioned the following: The sulphur dioxide is first absorbed by a basic sulphide, such as calcium sulphide, in the wet or dry state, thus producing calcium sulphite and free sulphur. Subsequently the sulphite is reduced (using hydrocarbon), thus resulting in the regeneration of the calcium sulphide ready for use over again. (See also *C.T.J.*, 1931, **88,** 631.)

The "Chance" process for recovery of the sulphur in alkali waste (resulting from the old superseded Leblanc process) is based upon its treatment as mixed into a thin paste with water, with carbon dioxide or lime-kiln gas (which largely consists of that body) under pressure in several successive vessels. The carbon dioxide at first decomposes the calcium sulphide of the waste, liberating hydrogen sulphide, and this passing into the next vessel forms soluble calcium hydrosulphide, which in turn is decomposed by carbon dioxide, so that a series of interactions is involved as follows:

$$\begin{aligned} CaS + H_2O + CO_2 &= CaCO_3 + H_2S \\ CaS + H_2S &= CaS_2H_2 \\ \text{and } CaS_2H_2 + CO_2 + H_2O &= CaCO_3 + 2H_2S. \end{aligned}$$

The sulphuretted hydrogen so generated (in the proportion of two volumes for each one of carbon dioxide), although mixed with atmospheric nitrogen and carbon dioxide, is rich enough to burn into sulphur dioxide, which can be utilized for making sulphuric acid. Alternatively, the H_2S gas in admixture with air is passed over a suitable contact mass of iron oxide in the "Claus" kiln, and thus oxidized to water and sulphur ($2H_2S + O_2 = 2S + 2H_2O$). (See A. M. Chance, *J.S.C.I.*, 1888, p. 162.)

Another process depends upon the fact that when sulphur dioxide is passed over sulphide ore the latter is oxidized, ferric oxide and free sulphur resulting therefrom. (See Gas (Coal) and reference to Power-Station Sulphurous Gas, pp. 878-879.)

Carbon Disulphide—See Carbon Disulphide, Mercaptans, and Thiocyanides.

SULPHUR BURNERS—See Sulphur Oxides, p. 874.

SULPHUR DYES—See Dyes and Dyeing.

SULPHURETTED HYDROGEN—See Sulphur Compounds, p. 881.

SULPHURIC ACID—See Sulphur Compounds, p. 876.

SULPHURIC ACID TUBE—See Drying Tubes.

SULPHUROUS ACID—See Sulphur Compounds, p. 875.

SULPHURYL—The divalent radical $:SO_2$ occurring, for example, in sulphuryl chloride (SO_2Cl_2).

SULPHURYL CHLORIDE (SO_2Cl_2)—Obtained by the direct union of chlorine and sulphur dioxide at 30° C., bone charcoal or activated wood charcoal serving as a good catalyst. Sulphur dioxide and chlorine are continuously dissolved in a body of liquid sulphuryl chloride with activated carbon in suspension at ordinary temperature of the air, the liquid being subsequently filtered off from the carbon. Its preparation is the subject of an article by T. H. Durrans, who found that when the mixed gases are passed into anhydrous alcohol-free ethyl acetate, sulphuryl chloride is readily produced in quantity (*J.S.C.I.*, 1926, p. 3477). It is a colourless liquid of b.p. 70° C., fumes in the air, and is decomposed by water, yielding hydrochloric and sulphuric acids. There has been some talk of using this process for the manufacture of these two acids where local conditions are suitable.

It is a vigorous chlorinating agent, and used in the dyeing industry, manufacture of acetic anhydride and for vulcanizing rubber.

SULPHYDRATES (Hydrosulphides)—See Hydrosulphides.

SUMAC (*Rhus coriaria,* N.O. Anacardiaceæ)—A tanning material in the form of a greenish powder prepared from the dried leaves and twigs of various shrubs and trees of the *Rhus* order, found in Sicily, Italy, Spain, Greece, U.S.A., etc. The sumac already named and that from Central Italy (*Rhus cotinus*) are the most valued for their tannin content. The *R. cotinus* leaves and twigs yield "young fustic." The American production is obtained from various species, the best known being that described as "white sumac" (from *Rhus glabra*), the berries of which are used in medicine. "Tanners' Sumac" is a name given to the *Coriaria myrtifolia* found in the South of Europe. The tannin content of good sumac ranges from 25 to 28 per cent., and sometimes considerably higher. A brown-coloured extract of 52° Tw. is prepared commercially, and others of decolourized character are available. It is also used in dyeing, calico-printing, and the manufacture of ink. (See H. P. Trevethick on "Oil of Sumac from the Berries" (*Analyst,* 1931, **56,** 614), and Fustic.)

SUMAC WAX—See Waxes (Japan).

SUNFLOWER OIL (from *Helianthus annuus,* N.O. Compositæ) is pale yellow, slow drying, of sp. gr. 0·924, sap. v. 189 to 193; ref. ind. 1·461 at 60° C.; i.v. 129 to 132; acet. v. 14·5; soluble in alcohol, ether, etc. According to a published analysis it contains 86·6 per cent. unsaturated acids, 7·1 per cent. saturated acids, and its glyceride contents as follows: oleic, 33·4 per cent.; linolic, 57·5 per cent.; palmitic, 3·5 per cent.; stearic, 2·9 per cent.; arachidic, 0·6 per cent.; and lignoceric, 0·4 per cent. It is produced in Russia, some 2,700 square miles being devoted to its cultivation; also in China, Italy, the U.S.A., and India. The seeds yield about 22 to 28 per cent. of the oil, and the water-free seeds from 26 to 30 per cent. oil, which is described as a good lubricant, and when polymerized does not gelatinize; also said to be as good as olive oil for edible purposes, and used in making soaps, lubricants, varnishes, and illuminants, and for oiling wools. (See *B.C.A.*, 1931, B, 31.)

SUNLIGHT—See Ultra-Violet Rays.

SUPA OIL—From the tree *Sindora Wallichii,* Beuth (Philippine Islands); contains a mixture of sesquiterpenes, a crystalline triacetone ($C_{30}H_{62}$), etc. (See Henderson and others, *J.C.S.*, 1926, p. 3077.)

"SUPER"—A prefix meaning "higher," and applied to compounds containing unusually large proportions of some constituent or radical, such as superphosphate of calcium. (See Super-Saturation.)

"SUPERAC"—A proprietary rubber accelerator.

"SUPERAM"—A dry neutral fertilizer prepared by neutralizing the acidity of superphosphate with dilute gaseous ammonia (3 to 5 per cent.), which combines partly with the free phosphoric acid and partly with the phosphoric acid of the monocalcium phosphate; 97 per cent. of its total phosphoric acid content is said to be soluble in citric acid and 76 per cent. in water.

"SUPERBASIQUE METAL"—A modification of cast iron, having a greater resistance to the action of alkaline solutions.

"SUPERCEL"—Trade name of an inert and insoluble material for mixing with liquids to assist pressure filtration.

"SUPERMISER"—A combination feed-water and air pre-heater for use with Lancashire boilers.

"SUPERNEUTRAL METAL"—A silicon-iron alloy suitable for the construction of nitric acid condensers, etc.

SUPERPHOSPHATE (OF LIME) is an admixture containing soluble acid phosphate of calcium ($CaH_4(PO_4)_2$), prepared in large quantities for use as a fertilizer, by treating mineral phosphates (such as sombrerite, apatite, and coprolites), bones, etc., after grinding, with about two-thirds of their weight of sulphuric acid of sp. gr. 1·55 to 1·60. The grinding of phosphate rock by the so-called "ring and roller" type of mill, which is particularly suitable, gives from 80 to 95 per cent. per 100 mesh in different works. The mixture thus produced is one of calcium sulphate with calcium monophosphate:

$$(Ca_3(PO_4)_2) + 2H_2SO_4 + 5H_2O = 2(CaSO_4 2H_2O) + CaH_4(PO_4)_2, H_2O,$$

but if a larger quantity of sulphuric acid is used, the phosphate is converted into tribasic phosphoric acid, so that the product is of varying composition.

A mixture now generally used consists of 105 parts acid of 115° Tw. or 66·53 per cent. H_2SO_4, and 100 parts of ground phosphate rock.

Bone charcoal, which has been used for decolourizing purposes as ordinarily prepared—viz., by charring bones—still retains its calcium-phosphate constituents, and can be utilized by this method for the production of "superphosphate."

The total consumption amounted in the United Kingdom to 750,000 tons in 1919, the world's production at about 15 million tons, and the production in Great Britain and Ireland in the year 1929-30 about 576,000 tons. The free phosphoric acid in a good superphosphate

SUPERPHOSPHATE (OF LIME) (*Continued*)—

should amount to less than 1 per cent., and the water should not exceed 10 to 12 per cent.; the strength being generally expressed in percentage of P_2O_5 soluble in water and in ammonium citrate, but 80 per cent. should be soluble in water.

By the use of phosphoric acid instead of sulphuric acid, "double acid phosphate," containing 40 to 50 per cent. soluble phosphoric oxide, is obtained. It is essentially a monocalcium phosphate $CaH_4(PO_4)_2$. (See *C.T.J.*, 1926, **79**, 369 and 529.)

There are grades of phosphates manufactured as fertilizers varying from 30 to 35 per cent. water soluble; another variety containing 4 per cent. potash is particularly suitable for grass and clover. The idea that superphosphate causes or encourages soil acidity has been demonstrated as mistaken.

It is reported that bags which have contained superphosphate and are liable to lose colour and become weak by exposure to sunlight may be rendered fit for use over again if, after emptying, they are immersed in a weak bath containing 10 lbs. soda crystals or 4 lbs. soda ash in 50 gallons water.

The change in the water-soluble phosphoric acid content of superphosphate during storage is the subject of a paper by Shōji, Suzuki, and Nanai (see *B.C.A.*, 1931, B, 18). (See also description of a modern American plant for the manufacture of superphosphate (*C.T.J.*, 1929, **84**, 30); an American view of the future of this industry by K. D. Jacob (*Ibid.*, 1929, **85**, 81); W. Stollenwerk (*B.C.A.*, 1927, B, 554); and Fertilizers.)

SUPER-SATURATION—See Crystallization and Solution.

"SUPRARENIN"—See Adrenalin.

SURFACE CHEMISTRY—See Colloid Chemistry, Capillary Attraction, Catalysis, and Lubrication.

SUSPENSOIDS—See Colloid Chemistry.

SWEAT—Exudation from the skin, being water containing about 2 per cent. solid matters, including sodium chloride, acetic, butyric, formic, lactic, and other acids, fatty matters, and some other excretory products.

SWEET POTATO (*Ipomœa batatas*, Poir, N.O. Convolvulaceæ)—A tropical climbing plant, the thickened roots of which contain much starch. So-called "Natal cotton" is obtained from the seeds of another species of batatas. (See J. R. Stubbs, *Analyst*, 1926, **51**, 400.)

SWELLING AGENTS—For industrial articles like rubber and cellulose esters. (See W. B. Lee, *J.S.C.I.*, 1930, **49**, 226 T.)

SYLVANITE (Graphic Tellurium)—A gold, silver, and tellurium ore [$(Ag,Au)Te_2$] found in Transylvania, Colorado, and elsewhere; crystal system, No. 5, and sp. gr. 5·7 to 8·3.

SYLVESTRENE (Carvestrene)—A terpene which has been synthesized and boils at 175° C. It has generally been regarded as the chief con-

SYLVESTRENE (*Continued*)—
stituent of genuine Russian and Swedish turpentine oils. It gives a fine blue colouration with acetic anhydride and strong sulphuric acid. A recent investigation would make it appear that sylvestrene is absent from natural terpenes, and that the substance in question is carene—a dicyclic terpene ($C_{20}H_{32}$) which occurs in Indian and German turpentines and yields *d*-sylvestrene upon decomposition. (See Perkin and Tattersall (*J.C.S.*, 1907, p. 480); Rao and Simonsen (*J.C.S.*, 1925, cxxvii., 2494); H. Weinhaus (*B.C.A.*, 1929, A, 191); also Essential Oils and Terpenes).

SYLVIC ACID—A reputed constituent of resin (probably abietic acid).

SYLVINE—See Sylvinite.

SYLVINITE (**Sylvine**)—One of the Stassfurt salts containing potassium chloride, crystal system, No. 1, and sp. gr. 2·0. (See Potassium.)

SYMBOLS—See List of Physico-chemical Symbols adopted by the Chemical Society (*J.C.S.*, 1921, **119**, 502-512; Supplementary Numbers, 1930, 1-4; 1931, 1-4); Chemical Interactions, Elements, and Formulæ.

SYMMETRY—See S. H. C. Briggs on "The Significance of Symmetry" (*Chem. and Ind.*, 1929, **48**, 108); also Asymmetry and Crystals.

SYMPATHETIC INK—See Inks and Cobalt Compounds.

SYNAPTASE (**Emulsin**)—See Amygdalin, Emulsin, and Glucosides.

SYNTANS—See Tanning, p. 894.

SYNTHESIS—The chemical building up or construction of elements into compounds, or of compounds into more complex bodies, and not necessarily the reverse of analysis or decomposition. The production of rust upon iron is an act of synthesis, by which the oxygen and other constituents of the air enter into chemical combination with the iron; and the formation of verdigris on copper exposed to damp air is another act of synthesis.

When hydrogen gas is burned in the air it forms water synthetically by chemical combination with the atmospheric oxygen. When lime is heated to a certain temperature in a current of carbon-dioxide gas, they enter into combination, forming calcium carbonate by synthesis.

Among substances which have been built up synthetically are acetic acid, acetylene, alcohol, alizarin, citric acid, indigo, salicylic acid, urea, uric acid, vanillin, and a very great number of coal-tar colours and other compounds, etc.

SYNTHETIC PETROL—See Fuel (Liquid), Motor Spirit, and Synthol.

SYNTHETIC RESINS—See Gums and Resins.

"**SYNTHITE**"—A proprietary amber-coloured synthetic resin used as an electrical varnish and insulating material.

"**SYNTHOL**"—A German fuel prepared from water-gas by heating to 400° to 450° C. in an autoclave, under a pressure of 150 atmospheres in presence of a catalytic mixture of iron borings and potassium carbonate,

"SYNTHOL" (*Continued*)—

followed by distillation of the dry product which is thus obtained. It is a complex mixture of alcohols, aldehydes, ketones, etc., accompanied by about 2 per cent. of liquid hydrocarbons. The distillate mixed with an equal part of benzol is said to be a good motor fuel. Later reports state that the cheapest gaseous mixture has been found to be one of coke-oven and blast-furnace gases (F. Fischer, *C.T.J.*, 1931, **88,** 124). (See also H. Nielsen (*B.C.A.*, 1926, **45,** B, 652); Alcohol (Methyl), Motor Spirit, and Fuel (Liquid).)

SYNTONIN—An acid albumin insoluble in water, prepared from muscle fibrin by the action of dilute hydrochloric acid.

TABLE SALT (Common Salt)—See Sodium (Chloride).

TACHYDRITE—A magnesium-calcium salt ($2MgCl_2,CaCl_2,12H_2O$), occurring in the Stassfurt deposits; crystal system, No. 3, and sp. gr. 2·0.

TAIFUSHI OIL—The *Oleum gynocardiæ* (*Oleum chaulmoogræ*) of the Japanese pharmacopœia contains as its chief constituents glyceryl chaulmoograte and hydnocarpate, together with some palmitin, and is surmised to be obtained from the seeds of *Hydnocarpus anthelmintica* (not from *Taraktogenos kurzii,* which is the source of the genuine chaulmoogra oil). Its sp. gr. is 0·9427 to 0·9447; m.p. 26° to 29° C.; sap. v. 191, and i.v. 88 to 90 (Hanus).

Pure chaulmoogric acid ($C_{18}H_{32}O_2$) melts at 68° C., has an i.v. 90·1, and specific rotation of $+56°$; and pure hydnocarpic acid ($C_{16}H_{28}O_2$) melts at 59° C., has an i.v. 100·2, and specific rotation $+68·1°$. (See A. Marcan on the "Oil of *Hydnocarpus illicifolia*" (*J.S.C.I.*, 1926, **45,** 305 T), and Chaulmoogra Oil.)

TALC ($3MgO,4SiO_2.H_2O$)—A mineral of crystal system, No. 4, and sp. gr. about 2·5 to 2·8, deposits of which are found in Scotland, Canada, the U.S.A., Italy, Spain, Norway, etc., composed of hydrous magnesium silicate, published analyses of which are as follows:

	Per Cent.	Per Cent.
SiO_2	63·2	63·5
MgO	28·0	31·7
Moisture, etc.	8·8	4·8
	100·0	100·0

The most valuable type is stated to occur in the Madoc area of Ontario, and is of sufficient purity for use in making toilet preparations and finishing of laces, etc., while the commoner variety, known as soapstone, is sometimes used as a lining for furnaces. The Canadian variety is stated to lack the lustre of the Italian product.

The more laminated varieties, being transparent and incombustible, are of considerable utility for making stove-windows, goggles, lamp chimneys, and phonograph diaphragms. The world's production in 1918 amounted to 296,478 metric tons.

Talc powder, pearly in appearance and unctuous to touch, forms a very nice absorbent basis, and the higher grades are used in preparing

TALC (*Continued*)—
toilet preparations; others, in crayon form, are used in making French chalk and for lubricating, but about 90 per cent. of the talc mined is ground to flour and used in the manufacture of opaque paper, moulded rubber goods, foundry facings, and in the roofing trade. "Indurated talc" or "talc slate" is a variety which is not of laminated character, but resembles steatite and is used similarly. (See French Chalk, Soapstone, and Steatite.)

TALCUM—See Magnesium (Silicate).

TALL OIL—A by-product obtained by hydrolysing the soap separating from black-liquor in the sulphate-cellulose process—probably identical with "talloel." (See Cellulose and Paper.)

"TALLOEL"—A liquid, resin-like body produced during the manufacture of cellulose from wood by the sodium sulphite process, which by hydrogenation yields fatty acids suitable for soap-making. (See Paper.)

TALLOW—The name applied to the harder varieties of fats, such as the suet of the ox and sheep and the vegetable cacao fat. It is separated from the cellular tissue, with which it is associated in suet, by melting.

Beef tallow has a sp. gr. 0·943 to 0·952, sap. v. 193 to 200, and i.v. 38 to 46.

Mutton tallow has a sp. gr. 0·937 to 0·953, sap. v. 192 to 195, and i.v. 35 to 46.

Tallow melts at from 41·2° to 52° C., has a ref. ind. of 1·451 at 60° C., and consists of a mixture of glycerides. A sample of mutton tallow recently examined showed the mixed fatty acids to consist of myristic, 4·6 per cent.; palmitic, 24·6 per cent.; stearic, 30·5 per cent.; oleic, 36·0 per cent.; and linolic, 4·3 per cent. (Collin, Hilditch, and Lea on "The Component Glycerides of a Mutton Tallow," *J.S.C.I.*, 1929, **48,** 46 T).

It is used in process engraving and the leather trade, also for making soaps and candles.

Rambutan tallow, from the seeds of *Nephelium lappaceum J.* of Ceylon, is stated to contain the normal (fatty) eicosanic acid ($C_{19}H_{39}CO_2H$). (See Banks and Hilditch on "The Glyceride Structure of Beef Tallows" (*Biochem. J.*, 1931, **25,** 1168); Fats and Vegetable Tallow.)

TALLOW-SEED OIL (**Stillingia Oil**)—See Vegetable Tallow.

TAMARIND—The preserved pulp of the fruit of *Tamarindus indica,* N.O. Leguminosæ (East and West Indies), cultivated in many warm countries and containing citric, tartaric, and malic acids, etc.; used in medicine as a laxative and in sauce-making.

"TANKOSCOPE"—A new American lighting device for viewing the inside of barrels, etc.

TANNASE—The name given to the active principle (of presumably enzymic character) secreted or formed by certain mould fungi, notably *Aspergillus niger* and *Penicillium glaucum,* which effects the decomposition

TANNASE (*Continued*)—

of gallo-tannin, gallic acid being produced quantitatively. Yeast secretes a similar principle. (See Amylo Process, p. 22.)

TANNIC ACID (known also as **Digallic Acid** and **Gallotannic Acid**) has been described as probably a penta-digallol derivative of glucose and is really one of the tannins. It is a colourless, amorphous, glistening substance, being a sugar ester of complex constitution which darkens when heated and decomposes at about 215° C. The formulæ $C_{10}H_{14}O_9$ and $C_{27}H_{22}O_{17}$ (Strecker) have been respectively assigned to it, and it is claimed to have been synthesized.

According to Nierenstein, glucose is not an essential part of gallotannin, and the last-named body he describes as a polydigallol-leucodigallic acid anhydride, which may or may not exist as a glucoside. (See *Chem. and Ind.*, 1926, **45**, 221.)

As prepared from gall-nuts (produced on the leaves and buds of oak-trees by puncture of insects of the genus *Cynips*) by extraction with water or with water and alcohol, it yields gallic acid and *d*-glucose when boiled with dilute acids. It is also a constituent of tea, sumac, catechu, etc.; is used in medicine; said, in aqueous solution of 2·5 per cent., to be a good application for burns and scalds; and employed also in the textile and tanning industries. (See *Ind. Chem.*, 1929, v., 480, Gallic Acid, Tannase, and Tannins.)

TANNING is an important industry, as indicated by the fact that in 1918 about 8,000,000 hides and calf skins of the value of £30,000,000 were tanned in the United Kingdom. "Kips" of intermediate size are the hides of small East Indian buffalo. The common method of curing hides is that of dehydration by use of common salt, and unless the hides are thoroughly clean its penetration is more or less prohibited, thus giving rise to or promoting the affection known as "red heat," brought about by action of halophilic bacteria. (See D. J. Lloyd (with others), *B.C.A.*, 1930, B, 251.) It has been found that this trouble can be more or less obviated by the use of a small proportion of naphthalene mixed with the salt.

The disinfection of hides so as to rid them of anthrax spores has been a troublesome affair until lately, but a process has now been devised which appears to be perfectly efficient.

The operations involved in practical tanning vary widely, and the following notes give only a general account. After soaking to soften and to remove blood and lymph, sheep skins are painted on the fleshy side with a mixture of slaked lime and sodium sulphide or calcium hydrosulphide, and then the wool is pulled, leaving the skin, or "pelt." Attention has been drawn to the advantage of using calcium chloride as an addition to sodium sulphide depilatory mixture. After washing, the pelts are steeped for some days in lime liquor, and, after rubbing off the hair, subjected to a mechanical operation ("fleshing") to remove all adhering flesh. After careful washing to remove the lime as far as possible, the skins are ready for "bating" or "puering," to render them soft and supple by removal of hair sheaths, sebaceous glands,

TANNING (*Continued*)—

muscles, sweat ducts, etc., held together by elastic fibres—a process which is of a fermentative character, carried out by dressing with dog or fowl dung or other material comprising tryptic enzymes and several synthetic substitutes. Another mixture for bating consists of 65 per cent. ammonium chloride with wood-fibre, dry pancreas, and a little castor oil.

"Liming" hydrolyses proteins to peptones in the first stage, and the bacteria contained in old limes cause further hydrolysis to amines and amino-acids, so that this action approaches that of "bating," which hydrolyses the proteins to polypeptides, peptides, and amino-acids, which take no part in the tanning process. (See J. Hugonin, *B.C.A.*, 1927, B, 342.)

Both the red sulphide of arsenic (realgar) and the yellow sulphide (orpiment) can be used in place of sodium sulphide in connection with the liming process, but as they are not soluble by themselves, the lime has first of all to be slaked, and then the arsenical sulphide is added, thus producing a mixture which has very similar effects to those produced by sodium sulphide.

It has been ascertained that the addition of ammonium chloride or sulphate or common salt in small proportions increases the activity of the proteolytic enzymes in the bating process.

After drenching in a fermenting infusion of bran, the skins are ready for treatment with the tan liquor, which may be an infusion of sumac, other tanning materials which are used being barks, gambier, myrobalans, valonia, and extracts, such as kino, and those of oakwood, chestnut, and quebracho. Borax can also be used as a soft antiseptic soak, in common with boric acid, in course of deliming. The addition of hydrochloric acid, lactic acid, or sulphuric acid to the tan liquors with the object of neutralizing lime carried over from the liming process has proved beneficial.

The preliminary wet treatment of hides and skins involves complicated enzymic and bacterial action, freeing the so-called collagen which has been described as "an aggregate of *cyclo*-peptide micelles." (See I. G. Farbenind (*B.C.A.*, 1926, B, 891); J. Knaggs (*B.C.A.*, 1930, A, 234); and D. J. Lloyd (*Chem. and Ind.*, 1931, **50**, 1042). In the process of tanning, the astringent principles enter into combination with the collagen (gelatinous or proteid) part of the skins constituting the fibrous tissues, thus producing leather. "Chamoising" of skins really consists of two processes—viz., one in which the collagen is converted into a non-hydrolysable body (or tannage properly so called), and a "filling" process by adsorption, in which a quantity of saturated glycerides lubricate the leather (P. Chambard and L. Michallet, *J. Soc. Leather Trade's Chem.*, 1927, **11**, 559).

The so-called quinone tannage is carried out by use of such substances as benzo-quinone, toluquinone, and naphthaquinone, these having the property of producing compounds of high molecular weight. In one modification of the process quinol in presence of alkali is used, while in another patented process chloranil is employed. (See S. Hilbert and F. Brauns, *B.C.A.*, 1925, B, 412.)

TANNING (*Continued*)—

The rough tannage of pelt by means of smoke is chiefly attributable to its formaldehyde and phenolic constituents.

Formaldehyde has been used in tanning, by reason of its coagulating and preservative effect on the collagen molecule, and a preliminary treatment of this sort does not interfere with the subsequent absorption of chromium as next referred to.

In this process, chromium salts are used for treatment of the prepared pelts, the bath consisting of a mixture of potassium or sodium dichromate with hydrochloric or sulphuric acid, followed by the application of sodium thiosulphate to effect the reduction of the chromium salt to a basic state or oxide in combination with the tissue. It is stated that after unhairing and pickling by immersion in a bath of dilute sulphuric acid and sodium chloride, skins can be completely tanned in two days by immersion in a bath of chrome liquor, consisting of basic chromic sulphate diluted to contain 17 grms. of chromic oxide per litre. The impregnation of the materials to be tanned is sometimes effected by electric endosmose, which is said to be available for the impregnation, with chromium or other metallic salts, of fabrics which have been treated with glue or gelatin, and that this method permits of the utilization of very dilute tanning liquors and greatly facilitates the process in point of time.

Unmordanted chrome leather is stated to have a greater affinity for acid and direct coal-tar dyestuffs than vegetable leather.

The nature of this process has been described as a precipitation of the positively charged micellions of chromium hydroxide by the oppositely charged colloidal protein hide substance. Schindler and Klanfer have discussed the processes of dyeing, neutralization, oiling, and pickling in the manufacture of chrome leather in their colloid aspect (*B.C.A.*, 1930, B, 678).

"Chrometan" is a proprietary reduced chrome made in liquid and crystalline forms. The ordinary liquid has a basicity of 144°, and the "basic" variety one of 96°; while, when dried, the crystalline variety contains 25 per cent. oxide of chromium.

The composition of chrome-tanned leather waste, with a water content of 50 per cent., is given as approximately—protein, 35 to 40 per cent.; Cr_2O_3, $2\frac{1}{2}$ to $3\frac{1}{2}$ per cent.; SO_3, 1 to $2\frac{1}{2}$ per cent.; and Dr. Stadlurger has described how a good quality of glue can be prepared from it. (See *Chem. and Ind.*, 1928, **47,** 1113.) (See also C. Stiepel (*B.C.A.*, 1931, B, 131); H. T. S. Britton on "Chrome Tanning," etc. (*Ind. Chem.*, 1927, iii., 411 and 452), and Tannins.)

According to a French patent, satisfactory tannage of hides can be effected by soaking in a 10 per cent. solution of hydro-fluosilicic acid. I. D. Clarke (*Ind. Eng. Chem.*, 1931, **23,** 62) states that the actual densities of different leathers are nearly constant at 1·327 to 1·433.

Artificial Leather is the name given to a number of composite materials made of any suitable base (such as cotton cloth, felt, or paper), coated with plastic masses of solutions of nitrocellulose, castor

TANNING (*Continued*)—

oil, and pigments in successive layers, the volatile solvents of the plasticizers being subsequently evaporated. Such products may be given an embossed covering in imitation of grained leather. Pyroxylin dissolved in amyl acetate can be used in admixture with castor oil; also other varieties of nitrated cellulose; blown linseed and other oils can be used in place of or in addition to castor oil; and a great variety of solvents are available, whilst pigments are introduced to give colour and body to the coverings. One particular variety made from a mixture of cellulose, leather, rubber, and wool is described (Report, Dept. of Scientific and Industrial Research, 1930-1931 (H.M. Stationery Office).)

Leather scrap has been used to some extent as a fertilizing agent, but the presence of chromium compounds is dangerous to vegetation, and other methods of disposal have been suggested, including destructive distillation, which yields a carbon black as final residue, from which the chromium can be recovered as chromic oxide by burning in a current of air, and from the distillate it is possible to extract ammonia, pyrolle, etc.

Other references: A. W. Thomas on "Chemical Nature of Vegetable Tanning" (*B.C.A.*, 1926, B, 989); R. F. Inness on "Sulphuric Acid in Vegetable-tanned Leather" (*J.S.C.I.*, 1929, **48,** 149 T); W. B. Pleass on "The *p*H Value of Tan and Lime Liquors" (*J.S.C.I.*, 1929, **48,** 152 T); A. Küntzel on "Action of Pickles" (*B.C.A.*, 1930, B, 873); Küntzel and Bucheimer on "Preparation and Properties of Raw Collagen" (*B.C.A.*, 1930, B, 874); D. J. Lloyd on "Tannery Waste" (*Inst. Chem. Eng.*, December, 1930, p. 45); Wilson and Daub on "The Micro-structure of Leather" (*B.C.A.*, 1926, B, 504); W. T. Lattey on "Leather Japanning" (*J.S.C.I.*, 1926, **45,** 377); E. J. Keiner on "Leather Colouration" (*C.T.J.*, 1928, **82,** 625); M. C. Lamb on "Dyeing of Gloving and Clothing Leathers" (*Ind. Chem.*, 1927, iii., 389, and *B.C.A.*, 1928, B, 707); P. I. Smith on "A Study of Enzymes in the Leather Industry" (*Ind. Chem.*, 1929, v., 311); J. B. Kershaw on "Tannery Waste Disposal" (*Ind. Chem.*, 1926, ii., 122); Tannery Waste Disposal Committee of Pennsylvania (*J. Am. Leather Chem. Assoc.*, 1931, **26,** 70-110); N. L. Wright on "The Manufacture of Vegetable Tanned Sole Leather" (*Ind. Chem.*, 1926, ii., 477); M. Kaye on "Preservation of Hides with Brine and Salt" (*J.S.C.I.*, 1929, **48,** 141 T); V. N. Patwardhan on "Salt Stains on Indian Hides and Skins" (*Chem. and Ind.*, 1931, **50,** 722); G. D. McLaughlu (with others) on "Bating" (*B.C.A.*, 1929, B, 830); M. Bergmann on "Red Discoloration of Salted Hides" (*B.C.A.*, 1930, B, 433); Burton and Robertshaw on "Functions of Oil and Fats in Currying, etc., of Leather" (*B.C.A.*, 1930, B, 628); R. F. Innes on "Deterioration of Vegetable-Tanned Leather on Storage" (*Analyst*, 1931, **56,** 827); R. S. Edwards on "Water Permeability of Leather" (*Ibid.*, p. 828); M. C. Lamb (with others) on "Leather Dyeing" (*Leather World*, February 4, 1932); H. G. Bennett on *Animal Proteins* (Baillière, Tindall and Cox); *Practical Tanning*, by A. Rogers (Crosby Lockwood and Sons); *Leather Manufacture*, by A. Watt (Crosby Lockwood and Sons); *Some Scien-*

TANNING (*Continued*)—
tific Aspects of Tanning, by J. T. Wood (Lecture, Inst. of Chem., November 24, 1920); *The Chemistry of Leather Manufacture*, by J. A. Wilson (Chem. Catalog. Co., Inc., N.Y.); *Practical Leather Chemistry*, by A. Harvey (Crosby Lockwood and Co.). (See also Leather Cloth, Osmosis, Pyroxylin, Tannins, and Tawing.)

TANNINS—A generic name given to astringent principles of the bark and some other parts of trees and shrubs (such as algarobilla, canaigree, chestnut, divi-divi, the doga tree of the Fijian Islands, eucalyptus, gambier, hemlock, larch, mangrove, mimosa, oak, osage, pine, quebracho and sumac), which combine with the collagen of animal hides to form leather. In Australia, wattle bark is the principal tanning agent employed by tanners, that of the golden wattle (*Acacia pycnantha*) and the black or green wattle (*A. decurrens*) being two of the more important varieties. Valuable tan barks are yielded by the *Eucalyptus diversicolor* (Karri bark), the mallee (*Eucalyptus occidentalis*), and other varieties of eucalyptus trees. Among tanning barks from Madagascar there are Rotra bark (*R. fotsy* and *R. meno*), containing 12·62 per cent. soluble tannins; Lalona (*Weinmannia bojeriana*), containing 13·75 per cent.; Filao (*Casuarina equisetifolia*), containing 15·31 per cent.; and Badamier bark (*Terminalia catappu*), containing 11·81 per cent. soluble tannins. The principal tannin is the so-called tannic acid. The astringent principles common to cutch and mimosa extract are either glucosides or associated substances of that nature, as both yield an unfermentable sugar upon hydrolysis. (See Tannic Acid.)

Tan substances can be roughly classified as "catechol tannins" (including birch bark, gambier, oak bark, quebracho, mimosa bark, mangrove, mallet bark, and hemlock), which yield catechol under the influence of heat, and "pyrogallol tannins" (including myrobalans, valonia, oakwood, sumac, chestnut, algarobilla, and babool), which yield pyrogallol under the influence of heat (J. A. Reavell). To prepare the extractives, the materials are subjected to crushing and leaching operations, so that, for example, 100 tons of mimosa bark will yield 100 tons of liquid extract containing 30 per cent. of so-called tan. Freshly cut western hemlock (*Tsuga heterophylla*) bark is stated to contain from 9 to 15·5 per cent. tannin, and that of spruce (Sitka) from 12 to 17·5 per cent. of the dry substance, the larger contents being found in summer. The tannin content of various South African materials is given by Choudary and Yoganandam (*B.C.A.*, 1926, B, 925). The tannin contents of green wattle and other South African tannery materials are given by C. O. Williams (*B.C.A.*, 1930, B, 730); see also *Ind. Chem.*, 1927, iii., 431.

A crystalline glucoside-tannin isolated from the seeds of *Paullinia cupana* has been assigned the composition represented by the empirical formula $C_{38}H_{36}O_{20}$ or $C_{37}H_{35}O_{18}.CO_2H$. Another crystalline tannin of the nature of a sugar ester, from the leaves of the *Acer ginnala*, named acertannin, is reported to have the composition $C_{20}H_{20}O_{13}$, and yields

TANNINS (*Continued*)—

gallic acid ($C_7H_6O_5$) and aceritol ($C_6H_{12}O_5$) upon hydrolysis. M. Tsujimura claims to have isolated from green tea a tannin of the composition $C_{22}H_{18}O_{10},2H_2O$ (*B.C.A.*, 1930, A, 1295). Hamamelitannin is the name given to a crystalline body of the composition $C_{20}H_{20}O_{14}6H_2O$. (See Freudenberg and Blummel, *J.C.S., Abs.*, 1925, p. 51.)

The tannin of the oak is an amorphous, reddish-yellow, acidic material, freely soluble in water, alcohol, and acetone, and its general nature is that of a glucoside. There is said to be a difference between the tanning properties of the natural oak bark and the extracts, due to the presence of enzymes in the former and absence in the extract, which are credited with the property of splitting up the larger tannin complex into a simpler substance more suitable for leather-making.

A number of so-called synthetic compounds are now used, some of which are of the nature of simple natural tannins, while others have nothing in common beyond the fact that they behave like them in contact with animal pelt. One of these latter is a body known as "Nerodol D" (dicresylmethanedisulphonic acid), another "Nerodol N" (dinaphthylmethanedisulphonic acid). There are other products produced by the condensation of the sulphonic acids of the higher hydrocarbons, as also phenols and cresols with formaldehyde, many of which are applicable to tanning; some of them, it is alleged, possessing advantages over vegetable products. It is not suggested that the new synthetic bodies ("syntans") will replace the natural tannins, but rather supplement them—a combination offering in many cases certain advantages. It is alleged that the synthetic compounds used in the early stages of tanning in conjunction with natural extracts, help in the rapid penetration of the natural tan, thus shortening the process duration. Some of them are also of value as bleaching agents, and remove iron and salt stains, but before they can be safely used, it is important to ascertain to what extent they may be destructive of hide substance, which is, of course, objectionable. Further particulars respecting some of these substances are given by S. R. Trotman (*Ind. Chem.*, 1928, iv., 499).

The following analytical figures are taken from an article by C. Ainsworth Mitchell (*Analyst*, 1923, **48,** 14):

	Moisture. Per Cent.	Total Extract. Per Cent.	Tannin. Per Cent.	Gallic Acid. Per Cent.	Total Pyrogallol Equivalent. Per Cent.
Valonia	13·15	49·0	46·0	3·0	17·3
Divi-divi	11·49	74·0	32·8	2·6	12·66
Commercial gall liquor . .	97·32	2·68	1·6	0·2	0·66
Commercial myrobalan liquor	97·08	2·92	1·62	0·5	0·87
Chinese tea	—	—	3·32	0·84	1·66
Tea (blend)	—	—	7·9	0·8	2·8

TANNINS (*Continued*)—

Various chemical plants have been designed for the leaching of barks, nuts, and wood for extraction of the tannin contents, including the Thornycroft patent apparatus.

It has become customary to determine as tannin, that portion of the water-soluble constituents of vegetable materials which will precipitate gelatin from solution, and will form compounds with hide fibre resistant to washing, but A. E. Jones has shown that "a positive gelatin test is no specific indication" of tannins, because such substances as gum arabic and inulin are also precipitated by gelatin (*Analyst,* 1927, **52,** 275). (See also W. Vogel, *B.C.A.*, 1931, B, 732.) Other methods are dealt with in papers by C. Ainsworth Mitchell on tannins, etc. (*Analyst,* 1923, **48,** 2, and 1924, **49,** 162).

The iron and ammonium citrate of the Brit. Pharm., together with ammonium acetate, has been advocated as the best test for real tannins, causing their complete precipitation from plant extractions. (See A. H. Ware, *Analyst,* 1924, **49,** 467.) The use of cinchonine sulphate as a determinant is referred to under the head of Cinchona (Cinchonine). Hide powder is collagen modified by liming, and the comparative tanning properties of various materials, as determined by a hide-powder test, is the subject of an article by E. Mezey. (See *J. Soc. Leather Trades Chem.*, 1925, **9,** 126-129); Atkin and Thompson (*B.C.A.*, 1927, B, 853); and R. Tatarskaja (*B.C.A.*, 1930, B, 433).)

Spent tan-bark is used in the manufacture of white-lead by the old Dutch process, and is of course available as fuel when suitably dried. There is also a patented process for utilizing spent tan as a reducing agent in the manufacture of one-bath chrome-tanning liquors. (See Catechu, Tannase, Tannic Acid, Tawing, and White Lead (p. 525).)

TANSY OIL—Distilled from the common herb *Tanacetum vulgare* (N.O. Compositæ), indigenous to Great Britain and Europe generally (0·15 per cent.), and containing thujone, camphor, borneol, etc.: a yellowish, thin oil of poisonous character, which rapidly darkens upon exposure to the air; soluble in alcohol and ether; sp. gr. 0·925 to 0·955 at 15° C.; opt. rot. +25° to +45° at 20° C.; used in medicine and perfumery.

TANTALITE (Columbite) [$(Fe,Mn)O(Nb,Ta)_2O_5$] of crystal system, No. 4, and sp. gr. 7 to 8—See Niobium.

TANTALUM (Ta) **and its Compounds**—Atomic weight 181·36; sp. gr. 16·6; m.p. 2,900° C. A rare metallic element found in nature in association with niobium in some Australian and Swedish minerals and in many other countries, including tantalo-columbates, which, as also the titano-columbates, are of great complexity. It is commercially available of 99·9 per cent purity; is a little darker than platinum; is nearly related to vanadium, but its use in making electric lamp filaments has been largely superseded by that of tungsten. It is not tarnished by air, nor attacked by acids, other than hydrofluoric acid; it combines with carbon to form a carbide, and at a red heat combines with hydrogen, nitrogen, and chlorine. Two insoluble oxides (Ta_2O_4 and Ta_2O_5) are known, and a number of other compounds. The metal is

TANTALUM (*Continued*)—

made by heating the double fluoride of tantalum and potassium in an electric furnace. Another method of preparing it in a cruder form and some further particulars of its compounds are given in a paper by Spitzin and Kaschtanov (*B.C.A.*, 1929, A, 1253). Its tensile strength is about 2½ times that of hard platinum. As the metal combines softness with workability, and exhibits great resistance to wet corrosion, it finds employment in place of platinum for making laboratory basins, etc., also in electrolytic rectifiers and other applications, and is superior to all other metals for manufacture of electrodes of high vacuum tubes. (See *C.T.J.*, 1927, **81,** 370; *Ibid.*, 1931, **88,** 77; and Niobium.)

"TANTIRON"—A hard and brittle brand of acid-resisting silicon-iron alloy; m.p. about 1,200° C.; density 6·9.

TAPIOCA—A starchy body, useful as food, obtained from the roots of *Jatropha Manihot* (*Manihot utilissima*), of the N.O. Euphorbiaceæ, cultivated in the West Indies and by the Chinese in Malaya. The flour contains some 75 to 80 per cent. of digestible carbohydrates, and is used for starch-making, as an adhesive, and in the textile industry. A similar product is known as *juca* or *yucca*. The name of tapioca is sometimes given to an Indian variety of granulated sago which is obtained from an entirely different plant. There are varieties of tapioca known as "sweet" and "bitter," the last named containing a larger content of hydrocyanic acid or cyanogenetic glucosides present in the flesh and cortex of the "bitter" variety, but only found in the cortex of the "sweet" variety. According to V. R. Greenstreet there are no vegetative characteristics to distinguish these varieties, the nature of the tuber appearing to depend on the locality where grown (*J. Inst. Chem.*, October, 1930). (See Cassava and Manioc.)

TAR—As shown under the heading of Coal (pp. 212-213), the characters of tars and their decomposition products necessarily vary according to the nature of the raw materials from which they are produced and the temperatures, pressures, and other conditions under which they are subjected to distillation.

In the "T.I.C." (lead bath) process of tar distillation a cushion of lead is placed on the still bottom, and the layer of tar is only about ½ inch in thickness, the process depending upon the rapid transference of heat enabling large throughputs to be obtained with continuous operation. Carbon growth on the still bottom is said to be thus prevented, and the tar so rapidly dehydrated that "priming" and consequent fire risk are avoided. There is an adequate arrangement for dealing with the pitch that results from the process.

When coal is heated out of contact with air, a point of temperature ranging from 230° C. (for brown lignites) to 330° C. (for bituminous coal) is reached when decomposition is made evident by the rapid evolution of gas, and at this stage "primary tar" is formed. In high-temperature carbonization in gas retorts or coke ovens, the primary tar vapours become heated to from 800° to 1,100° C., and thereby

TAR (*Continued*)—

undergo "cracking," thus giving rise to the production of further gases and the secondary or ordinary gas-tar.

The tar from vertical retorts differs in many respects from that obtained from the older horizontal retorts; the pitch resulting from its distillation is said to be less valuable for briquette making; the yields of benzol, toluol, and xylol are stated to be low, while the yields of creosote, pyridine, and tar acids are superior, although the separated tar acids, when extracted, undergo rapid discolouration and are therefore not so suitable for use in making disinfectants, etc. (See series of papers communicated to the Manchester Tar Conference (*J.S.C.I.*, 1926, **45**, 385-424 T and 441-462 T); J. Macleod and others (*B.C.A.*, 1927, B, 37); and *Ind. Chem.*, 1930, vi., 300.)

All high-temperature coal tars and the pitches derived from them contain varying percentages of free carbon resulting from decomposition of the volatile matter of the coal. For obtaining briquetting pitch the final tar temperature should not be above 280° to 300° C., and the time of exposure reduced to a minimum. (See Adams and Sach, *J.S.C.I.*, 1929, **48**, 337 T.)

The distillation method of separating tar constituents leads to from 30 to 60 per cent. pitch, whereas the solvent method cuts down the ill-defined materials to about 6 per cent.

Low-temperature tars are of more complicated composition than those obtained by high-temperature carbonization, and have a high content of tar acids making up from 10 to 30 per cent. of the total tar. Morgan, Pratt, and Ross have made a careful chemical study of low-temperature tar derived from coal of the Kinneil 6-ft. seam, and among other results have found that it contains a notable proportion of resinous products of varied nature which are likely to find industrial application.

The solvent method of separation of tar constituents has shown that these resinous bodies (resinenes), which disappear at higher temperatures, are accompanied by neutral oils, bases, phenols, and carboxylic groups, while the amount of naphthalene increases with rise of temperature.

Low-temperature tars vary in sp. gr. from 0·85 to 1·05 and have a calorific value of 16,500 to 17,000 B.Th.U. They can be used as fuel in Diesel engines after removal of the tar acids, and are reported to be of special value for the treatment and preservation of wood and other purposes. The hydrogenation of coal and the products of its low-temperature carbonization products is referred to under the heading of Coal, p. 212.

The coal tar production in Great Britain is about 2,000,000 tons annually, 1,350,000 of which is obtained from gas industries and 650,000 from the coking industries.

The British Road Tar Association's specification of a recent date provided that tar No. 1 for surface tarring and No. 2 for making tar macadam should fall respectively within the requirements as follows, blast furnace tar being excluded and the tar from manufacture of carburetted water-gas being limited to 10 per cent.:

TAR (*Continued*)—

	Tar No. 1.	Tar No. 2.
Sp. gr. at 15° C., not higher than ..	1·225	1·240
Sp. gr. at 15° C., not lower than ..	1·140	1·150
Water or ammoniacal liquor (per cent. by weight)	0·5	0·5
Other distillate (light oils) below 200° C., not more than (per cent. by weight) ..	1·0	1·0
Distillate between 200° and 270° C. (middle oils), within the range (per cent. by weight)	9·5 to 21·0	8·0 to 16·0
Distillate between 270° and 300° C. (heavy oils), within the range (per cent. by weight)	3·5 to 12·0	3·5 to 12·0
Phenols or crude tar acids, not more than (per cent. by volume)	5·0	4·0
Naphthalene, not more than (per cent. by weight)	6·0	5·0
"Free carbon," not more than (per cent. by weight)	20·0	6·0 to 21·0
Consistency or viscosity, within the range (seconds)	10 to 40	40 to 125

The consistency or viscosity to be determined by the standard consistometer at 30° C. or the equivalent on other instruments. Copies of other specifications can be obtained from the B.E.S.A., 28, Victoria Street, London, S.W. 1. (See W. E. Cone on "Road Tar" (*Chem. and Ind.*, 1928, **47,** 1048-1051), and W. J. A. Butterfield on "Road Surfacing Materials" (*J.S.C.I.*, 1928, **47,** 293 T).)

It is thought that the presence of from 10 to 20 per cent. free carbon in tar used for road work is desirable on account of its binding power and the resistance it lends to cracking of the surfaces; moreover, there is a tendency to incorporate a certain proportion of bitumen, such as the varieties known as "mexphalte" and "shellphate," both of which are derived from petroleum, and are soluble in carbon disulphide.

It has been pointed out that the present demand for tar for macadamizing and briquetting, and the extended use of water gas in respect of coal gas, have created such a situation that the extraction of ammonia from tar at many gas and coke-oven works can only be carried on at a loss.

In addition to ordinary gas tar, other varieties include blast furnace tar and those which result from the distillation of wood, the production of water gas, the conversion of coal by hydrogenation into oil, and by the conversion of coal or its residues after carbonization into liquids by the action of catalysts on mixtures of carbon monoxide and hydrogen.

The properties of blast furnace tar have been described by Edwards (*J.S.C.I.*, 1924, **43,** 143 T), and a further investigation has been made by A. Jaques, who found that the oil yielded upon distillation is heavier, yields a higher amount of the higher boiling fractions, and

TAR (*Continued*)—

contains from 25 to 30 per cent. or more of phenolic bodies (*Chem. and Ind.*, 1930, **49**, 1094).

Again, the various types of tar are not of equal value for road applications, that known as horizontal gas tar being best, coke-oven tar ranking second, and vertical retort gas tar lowest in value.

Acridine as a constituent of the heavy tar oils is supposed to be responsible for the affection known as pitch-cancer.

It has been stated that some 200,000,000 gallons of coke-oven tar made in the U.S.A. are burned annually as fuel by the producers.

Analyses of Umea (pale Swedish pinewood tar) and dark pinewood tars, by A. Caroselli and C. Schneider, are given as follows:

	Umea Tar. Per Cent.	Dark Tar. Per Cent.
1. Water soluble acids calculated as acetic acid	1·1	2·88
2. Unsaponifiable constituents (aldehydes, ketones, alcohols, and hydrocarbons):		
(*a*) Volatile in steam	8·66	13·96
(*b*) Not volatile in steam	32·7	31·01
3. Constituents insoluble in sodium carbonate (phenols):		
(*a*) Volatile in steam	3·32	5·94
(*b*) Not volatile in steam	—	18·48
4. Constituents soluble in sodium carbonate (phenols):		
(*a*) Soluble in ether and estimated as acetates	13·38	—
(*b*) Insoluble in ether	—	10·0
5. Acids:		
(*a*) Insoluble in ligroin (hydroxy acids) ..	12·8	8·9
(*b*) Fatty acids estimated as ethyl esters	4·8	4·0
(*c*) Resin	16·5	2·5

and it is inferred that the resin content and the whole composition of the tars are largely dependent on the source and method of production, the resin content being a very important factor. (See *Ind. Chem.*, 1925, i., 311; and Postovski and Peretz (*B.C.A.*, 1929, B, 704).)

Beech-wood tar contains so-called lignoceric acid ($C_{24}H_{48}O_2$), associated with a wax (lignocerin) which melts at 79°, and has been given the composition $C_{48}H_{96}O_2$.

According to the reports of the Alkali Inspectors for 1929, the tar distilled in that year amounted to 1,748,509 tons and the pitch produced to 511,973 tons.

Other References: Sinnatt and King (*J.S.C.I.*, 1925, **44**, 413 T); K. B. Edwards (*J.S.C.I.*, 1926, **45**, 54 T); Parrish and Rowe (*J.S.C.I.*, 1926, **45**, 99 T); S. A. Wikner (*C.T.J.*, 1927, **81**, 444 and

TAR (*Continued*)—

466); Dunstan and Shatwell on "Cracking" (*Ind. Chem.*, 1928, iv., 109); C. Chapman (*Ind. Chem.*, 1928, iv., 478); G. T. Morgan on "Chemical Studies of Tar" (*Chem. and Ind.*, 1928, **47**, 131; *C.T.J.*, 1930, **87**, 253; *Fuel*, 1931, **10**, 183; *J.S.C.I.*, 1932, **51**, 67 T); Morgan, Pratt, and Ross (*J.S.C.I.*, 1929, **48**, 29 T); Morgan, Pratt, and Pettet on "Aqueous Liquors from Low-Temperature Carbonization of Coal" (*J.S.C.I.*, 1929, **48**, 89 T), and Morgan and Pettet (*J.S.C.I.*, 1931, **50**, 72 T); Morgan and Megson on "Phenol-Formaldehyde Resins from Low-Temperature Tar" (*J.S.C.I.*, 1931, **50**, 191 T); F. J. Popham on "Cracking in the Distillation of Coal Tar" (*Ind. Chem.*, 1929, v., 179); Donnelly, Foott, and Reilly on "Tars from Pre-oxidized and Untreated Coals" (*J.S.C.I.*, 1929, **48**, 102 T); Morell and Eglof on "Cracking of Wood Tars" (*B.C.A.*, 1929, B, 583, and *J.S.C.I.*, 1930, **49**, 263 T); Chadder and Spiers on "Some Problems, etc., relating to Coal Tar" (*Chem. and Ind.*, 1930, **49**, 863); "'Hird' Continuous Tar Distillation Plant" (*Ind. Chem.*, 1930, vi., 105); Hurley and Matthews on "Low Temperature Tar as a Fuel" (*Chem. and Ind.*, 1931, **50**, 584); Herzenberg and Von Winterfeld on "Lignite Tar" (*B.C.A.*, 1931, B, 706); J. L. Wiltshire on "The Phenol Content of the Tars and Oils derived from Coal" (*J.S.C.I.*, 1931, **50**, 125 T); H. C. Dungey on "Cleaning of Tar Stills" (*C.T.J.*, 1931, **88**, 532); *An Investigation into the Nature and Properties of Coal Tar*, by Evans and Pickard (South Metropolitan Gas Co., 1931); J. M. Weiss on "Distillation of Coal Tar (U.S.A. Practice)" (*Chem. and Ind.*, 1932, **51**, 219 and 246); *Standard Methods for Testing Tar and its Products* (Standardization of Tar Products Committee, 166, Piccadilly, London, W.; Heffer and Sons, Cambridge); Bunbury and Davidson on *Industrial Applications of Coal-Tar Products* (Ernest Benn, Ltd.); Coke-ovens, Stockholm Tar, Wood (Distillation), and other references given under heading of Coal.

TAR ACIDS—A common designation for mixtures of phenol (carbolic acid) with cresols, used in respect of all constituents that may be extractable by caustic soda from coal-tar distillates. (See "Cracking of Tar Acids from Coal," by Morrell and Egloff (*J.S.C.I.*, 1930, **49**, 263 T and 267 T); Carbolic Acid, Cresylic Acid, and Tar.)

TAR SANDS—See Asphalt and Torbanites.

TARAXACUM OFFICINALE or **DANDELION**—Extract or infusion of dandelion root (*Leontodon taraxacum*), containing an active principle named taraxacin; used as a laxative and in making soft drinks.

TARRAGON OIL—A nearly colourless liquid, distilled from *Artemisia Dracunculus*; sp. gr., 0·900 to 0·949; opt. rot., +2 to +9; and ref. ind., 1·5161 to 1·517; soluble in alcohol and ether, and used in medicine and for flavouring. (See Wormwood.)

TARTAR—A name applied loosely to salts of tartaric acid, but more particularly to potassium bitartrate ($KHC_4H_4O_6$) which is deposited from fermenting grape juice and wines on long keeping. This is

TARTAR (*Continued*)—
known in commerce as "crude tartar" or "argol," and gives the white crystalline "cream of tartar" (when purified by being dissolved in water and recrystallized), which is used in medicine and in the dyeing and baking-powder industries. In admixture with varying proportions of saltpetre it is sometimes used in making the black and white fluxes which are used in metallurgical and assaying operations, and when pounded and mixed with chalk and alum it makes an excellent powder for polishing articles of silver. (See Argol.)

TARTAR EMETIC—See Antimony Compounds (p. 53).

TARTARIC ACID ($C_4H_6O_6$ or $CO_2H.CH(OH).CH(OH).CO_2H$) occurs in nature (either in the free state or in combination with potassium and calcium as tartrates) in many vegetable juices such as tamarinds, gherkins, mulberries, pineapples, unripe beetroot, and more particularly in grape juice in combination as potassium bitartrate. A considerable industry is carried on in Sicily, Spain, and other wine-producing countries in the production of tartaric acid from the lees containing potassium bitartrate and calcium tartrate. It is readily prepared in a crystalline state from this mixture by treatment with lime or calcium carbonate, followed by decomposition of the resulting calcium tartrate with sulphuric acid. When argol is used as the source, this crude tartar can be dissolved in hydrochloric acid and the solution then nearly neutralized with milk of lime, which causes the deposition of calcium tartrate, leaving potassium tartrate in solution. The calcium tartrate, after some purification, is decomposed by dilute sulphuric acid, causing precipitation of calcium sulphate and leaving the tartaric acid in solution ready for concentration and production thereby of the crystallized acid. (See A. Salmony, *C.T.J.*, 1927, **81**, 569.)

The world's production is estimated at some 20,000 metric tons a year, Spain producing about one-fourth of the total world's supply of raw acid material.

The common or *d*-tartaric acid found in nature is optically active, crystallizes in large prisms (as $C_4H_6O_6.H_2O$), and is soluble in water. It fuses at 170° C.; is decomposed at 180° C.; is used in calico-printing as a solvent for the mordant, and finds applications in making effervescent beverages and medicine.

Tartaric acid is known in four distinct modifications—namely, the dextro acid described above, the lævo acid of same melting-point, racemic acid, and an inactive form of m.p. 143° C. (See Argol, Racemic Acid, and Tartar.)

TAURINE ($C_2H_7HSO_3$)—A crystalline body soluble in hot water, found present in fæces, and easily obtained by the action of acids upon bile.

TAUROCHOLIC ACID ($C_{26}H_{45}NSO_7$)—A constituent of bile which is decomposed by boiling with acids, yielding cholic acid ($C_{24}H_{40}O_5$) and taurine ($C_2H_7NSO_3$). (See Bile.)

TAUTO—Prefix indicative of tautomeric form.

TAUTOMERISM—See Isomerism.

TAWING—The dressing of skins, or tanning processes with solutions of mineral salts such as alum or those of chromium; used particularly in respect of glove and kid leathers. (See Tanning.)

TAXINE—An amorphous alkaloid obtained in yield of 0·7 to 1·4 per cent. from dried yew-needles, stated to have the formula $C_{37}H_{51}O_{10}N$, and m.p. 105° to 110° C.

TEA—The dried leaves of plants of the genus Camellia, N.O. Ternstrœmiaceæ, including the two varieties *Thea sinensis* (China tea) and *C. theifera* (Assam tea), which are largely cultivated in China, Japan, India, and Ceylon. Tea contains an essential oil (which gives aroma to it), an active principle named theine (caffeine) ($C_8H_{10}N_4O_2$), legumin, and tannin, in varying proportions according to the nature of the tea and other circumstances attending its production. The amount of theine varies between 2·57 and 4·89 per cent. in dry Ceylon tea, 3·86 and 4·89 per cent. in Indian tea, and from 2·42 to 3·78 per cent. in Chinese tea, the tannin between 12 and 15 per cent., and the essential oil from ½ to 1 per cent. The tannin extracted from tea, when pure, has been described as a white substance which oxidizes in the air to a brown syrup, and is soluble in water, alcohol, acetone, etc., but insoluble in chloroform, benzene, and carbon disulphide, having a composition agreeing with the formula $C_{20}H_{20}O_9$. The Indian and Ceylon teas contain more tannin than the Chinese tea.

Taken in moderation, tea is a useful stimulant.

TEAK (*Tectona grandis,* N.O. Verbenaceæ)—A valuable, hard, durable wood found in Central and S. India, Burma, and Siam. The African variety from the west coast comes from *Oldfieldia Africana,* but is not so good as the best-known sort.

TEA-SEED OIL is expressed from the seeds of *Thea sasanqua* (about 24 per cent.), and is a clear, straw-coloured or yellowish oil, without odour or taste, closely resembling olive oil, for which it can be used as an adulterant, but, owing to the presence of a poisonous saponin body, it has been condemned in its crude state as an edible oil. Although botanically related to the plant from which tea is prepared, the two are quite distinct. There are several varieties on the market, and the Sasanqua oil from *Thea sasanqua* has a sp. gr. of 0·916 to 0·919, sap. v. of about 193·4 to 194, i.v. of 88 to 90, and ref. ind. of 1·471. It is used respectively as an illuminant, for soap-making, as hair oil, and for lubrication, and, when purified, for edible use.

The *Thea japonica* yields Tsubaki oil, which is very similar to tea-seed oil.

China supplies the largest quantity of the oil, and Japan has a small production. The oil from India and French Indo-China is obtained from the *Cammellia drupifera.* (See K. Hashi (*Analyst,* 1931, **56,** 325) and Heiduschka and Shu-Sheng (*B.C.A.*, 1931, A, 1341).)

TEA-TREE OIL—From *Leptospermum citratum,* Australia. (See *C.T.J.*, 1932, **90,** 106.)

"TECHNICAL METHODS OF CHEMICAL ANALYSES"—See Lunge and Keane's work, edited by Keane and Thorne (Gurney and Jackson, London).

TEETH—See Dentine.

TELEGRAPH—See Electricity, p. 295.

TELEPHONE—See Electricity, p. 295.

TELESCOPE—An instrument formed of several lenses so arranged as to magnify distant objects.

TELLURITE—See Tellurium.

TELLURIUM (Te) **and its Compounds**—Atomic weight 127·5; sp. gr. 6·27; m.p. 452° C. An element (credited with three isotopes) which occurs naturally to some small extent in pure crystalline form of No. 3 system, but is, for the most part, met with in combination in some rare minerals including *tellurite* (tellurium dioxide, TeO_2), *tetradymite* (bismuth telluride, Bi_2Te_3), *sylvanite* $(Ag,Au)Te_2$, and *melonite* (NiTe). It is also said to exist in mineral forms associated with gold in Hungary and Transylvania.

It is a bright white metal of lustrous appearance, soluble in nitric and sulphuric acids and strong potassium hydroxide; a poor conductor of heat and electricity; boils at a dull red heat, giving off a golden yellow vapour, and, when heated in the air, burns with a blue flame, forming the dioxide (TeO_2), which is stated to have a m.p. of 732·6° C., d^{20}_{4} 6·02. In general properties tellurium resembles sulphur and selenium. The metal can be prepared from bismuth telluride (Bi_2Te_3) by fusion with sodium carbonate and carbon followed by treatment of the resulting product with water; this gives a solution containing sodium telluride, and upon exposure to the air, metallic tellurium is deposited as a grey powder, which can be purified by distillation in a current of hydrogen. It is also obtained in a grey, brittle form by reduction of tellurium dioxide.

It does not tarnish in moist air, and finds uses in the making of high-resistance alloys, in electrical equipment, and the ceramic industries. In combination with hydrogen it forms hydrogen telluride (H_2Te), an offensive poisonous gas soluble in water, which is decomposed by heat and deposits metallic tellurium as a crystalline sublimate.

Two oxides are known (TeO_2 and TeO_3) and two corresponding acids, known as tellurous (H_2TeO_3) and telluric (H_2TeO_4), which are analogous to sulphurous and sulphuric acids. (For preparation of telluric acid see Meyer and Franke, *B.C.A.*, 1930, A, 1389.)

Two chlorides are known ($TeCl_2$ and $TeCl_4$) and corresponding bromides and iodides. (See J. H. Simons. *J.Amer.C.S.*, 1930, **52,** 3488.)

Tellurium derivatives of the aliphatic β-diketones are stated to be very active germicides (see G. T. Morgan (with others), *J.S.C.I.*, 1924, **43,** 304 T), and some of the tellurium compounds have been found to exercise a curative action in cases of syphilis. (See W. O. Kermack, *B.C.A.*, 1927, A, 587.)

TELLURIUM (*Continued*)—

It has been reported that the introduction of a tellurium compound into gasolene for use in high-compression motors of automobiles prevents the "knocking" that otherwise occurs in climbing inclines with the throttle open. Some other notes by "Omega" on the uses of tellurium will be found in the *C.T.J.*, 1926, **79**, 309.

TEMPERATURES (Critical)—See Gases (p. 392).

TEMPERATURES (Notable)—See Heat (p. 437).

TEMPERATURES (Regulation)—See Heat (p. 438).

TENNANITE—Mineral of composition ($4Cu_2S,AS_2S_3$), of crystal system, No. 1, and sp. gr. 4·5, occurring in some U.S.A. districts.

TENORITE—Mineral black copper oxide (CuO) found in some U.S.A. districts; sp. gr. 6·25.

TENSIMETER—An appliance used in determining vapour pressures.

TENSION (of Gases)—The force with which the particles or molecules tend to recede apart and to occupy a greater space. (See Gases, pp. 392-393.)

TERBIUM (Tb)—Atomic weight, 159·2. A rare element contained in *gadolinite, samarskite, euxonite,* and *monazite.* Two oxides (Tb_2O_3 and Tb_4O_7), a sulphate ($Tb_2(SO_4)_3$), chloride ($TbCl$), and nitrate [$Tb(NO_3)$] are known, the salts being hygroscopic and crystalline.

TEREBENE—A commercial product prepared from American or French turpentine by heating moderately with several successive small quantities of strong sulphuric acid until its action on polarized light is quite destroyed, and then, after washing, submitting to distillation. It is a mixture of hydrocarbons, of which inactive camphene is one and dipentene (C_5H_8) another.

TEREPHTHALIC ACID ($C_6H_6O_4$)—An oxidation product of turpentine, *p*-toluic acid, and cymene, which sublimes unchanged and is nearly insoluble in water and alcohol.

TERNE-PLATES—See Tin.

TERPENE HYDROCHLORIDE (Pinene Hydrochloride) ($C_{10}H_{16}HCl$) —A white crystalline body made by heating pinene ($C_{10}H_{16}$) with hydrochloric acid. It is soluble in alcohol, has a camphor-like odour and m.p. 125° C.

TERPENES ($C_{10}H_{16}$)—See I. W. Humphrey on "Terpene Chemicals" (*C.T.J.*, 1931, **88**, 331); F. Singleton (*Chem. and Ind.*, 1931, **50**, 839); *Natural Terpenes*, by J. W. Baker (Methuen and Co., London); *The Terpenes*, vol. i., by J. L. Simonsen (Cambridge Univ. Press); also Hydrocarbons (p. 456) and Turpentine.

TERPIN HYDRATE ($C_{10}H_{22}O_3$ or $C_{10}H_{20}O_2,H_2O$) is a colourless, crystalline substance, soluble in alcohol and ether, which melts at 118·2° C., and is a combination of water with a substance named terpin (m.p.

TERPIN HYDRATE (*Continued*)—

104·7° C.), which in its turn is prepared by boiling terpineol ($C_{10}H_{18}O$) with dilute sulphuric acid. It is prepared from oil of turpentine by the action of an alcoholic solution of nitric acid.

"TERPINE"—A commercial turpentine substitute, being a mineral spirit obtained by the distillation of Borneo petroleum, having much the same physical properties as turpentine spirit other than the odour. Sp. gr. 0·81 at 15° C., flash-point 88 (open cup), initial b.p. 142° C., and final b.p. 188° C.

TERPINENE—A terpene ($C_{10}H_{16}$) obtained by the action of alcoholic sulphuric acid on dipentene. It boils at 179° C., and is optically inactive.

TERPINEOL ($C_{10}H_{18}O$ or $C_{10}H_{17}OH$) is a liquid of alcoholic structure, allied slightly in chemical nature to menthol and carvone. It is stereoisomeric with geraniol, and occurs naturally to some extent; is readily made from terpene hydrate by the action of dilute acid or by action of dilute potash on limonene hydrochloride, and is extensively used in the synthetic perfumes industry, being the basis of the lilac and lily artificial products. It melts at 37° C., boils at 210° C., is soluble in alcohol and ether, and can be used as a plasticizer in alcohol and oil varnishes.

TERPINOLENE——A terpene—b.p. 183° to 185° C.—isomeric with dipentene.

TERRA ALBA—This term is variously used commercially in respect of kaolin, gypsum, burnt alum, or magnesia, but should be reserved for kaolin.

TERRA COTTA—Baked earth or clay in varieties of buff, yellow, and red colour. Articles made of it can be cleaned with sodium hydrosulphite.

TEST-PAPERS—Absorbent papers impregnated with litmus or turmeric; for testing alkalinity or acidity of fluids. (See Litmus, Turmeric Paper, and Volumetric Analyses.)

TEST-TUBES are thin glass tubes of special quality and various diameters ranging from about ¼ inch to 1 inch, sealed at the lower end, and sometimes provided with a lip at the upper end. They are chiefly employed, as implied by their name, for making tests with chemical reagents, and are capable, when containing liquids, of withstanding the direct application of flame, such as that of a Bunsen burner.

TETRACHLORETHANE (**Acetylene Tetrachloride**) ($CHCl_2.CHCl_2$) is a colourless, non-inflammable, poisonous liquid of sweet sickening odour, sp. gr. 1·62 at 4°, b.p. 144° C.; insoluble in water, but soluble in alcohol and ether, and prepared by one process from acetylene by the action of chlorine in presence of iron as a catalyst and subsequent distillation; it yields trichlorethylene by the action of lime. Tetrachlorethane is a good solvent of fats, oils, resin, rubber, etc., does not attack metals, and is used in making films, lacquered goods, and artificial silk. (See Solvents.)

TETRACHLORETHYLENE (**Perchlorethylene, Carbon Dichloride, Carbon Bichloride**) ($CCl_2.CCl_2$)—A colourless liquid solvent of ethereal odour, sp. gr. 1·628 and b.p. 119° C.; soluble in alcohol and ether, made by action of chlorine upon ethylene. (See Solvents.)

TETRADS—Quadrivalent elements. (See Valencies.)

TETRADYMITE (Bi_2Te_3)—Mineral bismuth telluride, sometimes occurring also in combination with bismuth sulphide (as $2Bi_2Te_3.Bi_2S_3$), of crystal system, No. 3, and sp. gr. 7·2. (See Bismuth.)

TETRA-ETHYL LEAD—See Motor Spirit.

"TETRAFORM"—Purified form of carbon tetrachloride for internal use.

TETRAHEDRITE (**Grey Copper Ore**)—See Copper.

"TETRALIN" (**Tetra-hydro-naphthalene,** $C_{10}H_{12}$)—An imperfectly saturated hydrocarbon liquid of pungent odour produced by the hydrogenation of naphthalene in the presence of a catalyst at 150° C. It is used as a solvent of waxes, resins, rubber, naphthalene, etc., also for removing printer's ink from old paper, as a substitute for turpentine in varnish and polish making, and as a benzol wash oil from coal gas. It boils at 205° C., is of sp. gr. 0·98, and has a flash-point of 79° C. As it dissolves 3 per cent. of its weight of sulphur at ordinary temperatures and 40 per cent. at 100° C., it can be used for extracting sulphur from spent oxide as produced in gas purification.

There is an intermediate product between "tetralin" and "dekalin" known as "tetralin-extra" (being a mixture of about 20 per cent. "tetralin" and 80 per cent. "dekalin"), which boils at 190° C., has a flash-point of 140° F., and a sp. gr. of 0·900. When used as a substitute for turpentine in paints, it is of importance to take care that the ingredients are quite free from manganese, as otherwise, it is stated, the white paints so made show a tendency to redden. (See "Dekalin" and Hydrogen (Hydrogenation).)

TETRAMINES—Bodies containing four amino groups (NH_2).

TETRATHIONIC ACID—See Sulphur (Oxides), p. 875.

TETRYL (**Tetranitroaniline**)—An explosive prepared by nitration of dimethylaniline or phenylmethylnitrosamine. A new process is described by L. Desvergnes (*B.C.A.*, 1931, A, 211).

TEXTILES—Excepting wool and cotton, adequate data with respect to many important properties of woven fabrics relative to humidity and temperature are wanting. The "Mullen" bursting test is employed in respect of tensile strength on strips and yarns, and shows that wool (ordinary and unshrinkable) and viscose give almost identical curves for moisture content; cotton and linen, being similar, having a corresponding value of about 7 per cent.; while "Celanese" is low, being only 6 per cent. at 70 per cent. R.H.

References: Occurrence and Detection of Certain Faults in Textile Fabrics, by O. S. Rhodes (*Chem. and Ind.*, 1932, **51**, 179); Atmospheric Influences on Various Fabrics, by H. Sommer (*B.C.A.*, 1927, B, 903). "Bleaching, Dyeing, Printing, and Finishing," by J. Ferguson (*Ind. Chem.*, 1926, ii., 177 and 358); "The Applica-

TEXTILES (*Continued*)—

tion of Emulsifying Agents in the Textile Industries," by S. R. Trotman (*C.T.J.*, 1928, **83**, 49); "Dischreit's Dyeing Apparatus for Textile Laboratories" (*Ind. Chem.*, 1930, vi., 41); "Dyeing of Millinery Materials," by E. Gillson (*Ind. Chem.*, 1928, iv., 223); "Fabric Mildew Prevention" (the second report of the Fabrics Co-ordinating Research Committee (H.M. Stationery Office) abstracted in *C.T.J.*, 1930, **86**, 438); "A Quick and Practical Routine Method of obtaining Cross-sectional Photographs of any Textile," by P. V. Perrott (*Ind. Chem.*, 1930, vi., 325 and 365); "Some Applications of Chemistry and Physics to the Examination of Hosiery Yarns," by R. H. Pickard (*Chem. and Ind.*, 1930, **49**, 989); "Fast Shades on Textiles," by W. Garner (*Ind. Chem.*, 1927, iii., 498); "Choice of Textile Soaps, by W. Garner (*Ibid.*, 1931, vii., 409); "Kiering of Vegetable (Cotton) Fibres," by G. Ullman (*B.C.A.*, 1931, B, 1006); Parker and Jackman (*Chem. and Ind.*, 1925, **44**, 1249, and 1926, **45**, 47 T); references by R. Mohr and M. Freiberger, respectively (*B.C.A.*, 1926, B, 534); *Textile Chemistry*, by F. J. Cooper (Methuen and Co., Ltd.); *Introduction to Textile Chemistry*, by H. Harper (Macmillan and Co.); *Dyeing of Textile Fibres*, by Horsfall and Lawrie (Ernest Benn, Ltd.); *Textiles on Test*, by J. G. Williams (Chapman and Hall); also Bleaching, Cotton, Kier Boiling, and Wool.

THALLIUM (Tl) **and its Compounds**—Atomic weight 204, but recently re-determined as 204·34 (Briscoe (with others), Proc. Roy. Soc., 1931, A, **133**, 440); sp. gr. 11·85; m.p. 301° to 303° C. It occurs to the extent of about 17 per cent. in *Crookesite*, associated with copper and silver as selenides (Cu_2Se_4,TlSe, Ag_2Se) (of crystal system, No. 1); also in many varieties of iron and copper pyrites, so that it can be obtained from the dust resulting from the roasting of pyrites. In one reported case, 4 lbs. of thallium was recovered from 1,500 tons of pyrites, the dust containing 0·25 per cent., equal to 1 part thallium per 1,000,000 parts of pyrites. It is obtained from the sulphate by immersing strips of zinc in the solution, when the thallium is deposited upon the zinc in the form of a spongy crystalline mass; also by treating thallium iodide with metallic sodium. It is soft, heavy, dissolves in nitric and sulphuric acids, makes a mark on paper as lead does, and is intermediate in properties between lead and the alkaline metals. Inasmuch as it undergoes oxidation in the air to black thallous oxide, it has to be preserved in water to keep its normal bluish-white lustre. It is said to have two isotopes (203 and 205).

There are two oxides, thallous oxide (Tl_2O) and thallic oxide (Tl_2O_3), the latter being a dark reddish powder, insoluble in water, formed when the metal is melted in presence of air.

Thallous Hydroxide (TlHO)—Made by dissolving thallous oxide in water, or adding a solution of barium hydroxide to one of thallous sulphate, and concentrating the filtrate from the precipitated barium sulphate; it crystallizes in yellow needles, is alkaline, and soluble in water.

Thallous Chloride (TlCl)—A white, slightly soluble substance formed

THALLIUM (*Continued*)—

when metallic thallium is heated in chlorine gas (when it burns) or by precipitation of a thallous solution with hydrochloric acid. There is another chloride (TCl_3), a colourless body obtained by passing chlorine through water containing thallous chloride in suspension, and concentration of the resulting solution, when it crystallizes out in combination with water ($TlCl_3,2H_2O$). This compound is used in the preparation of certain vermicidal compounds.

Thallium Sulphate is stated to be of value as a rat poison, but care must be taken to avoid skin absorption in handling bait treated with it as it is very poisonous. (See "The Toxicology of Thallium" (*Lancet*, December 20, 1930, p. 1340).)

Thallous Carbonate (Tl_2Co_3) is a crystalline body soluble in water obtained by evaporation of the hydroxide solution after saturation with carbon dioxide.

Thallous Phosphate (Tl_3PO_4) is obtained by precipitating a thallous solution with one of potassium phosphate.

The **Sulphide** (Tl_2S) is an insoluble black compound.

The **Acetate** has been used as a depilatory in cases of ringworm, etc.

"THANALITH" (and **"Thanalith H"**)—German water-soluble wood preservatives, containing fluorine, arsenical salts, and salts of nitro-derivatives of phenol. (See *Ind. Chem.*, 1931, vii., 293.)

THEBAINE (**Para-morphine**) ($C_{19}H_{21}NO_3$)—A white, crystalline, and very poisonous alkaloidal base, being morphine in which both phenolic and alcoholic hydroxyls are methylated. It melts at 193° C., is slightly soluble in water and alcohol, but soluble in chloroform and benzene. (See Opium.)

THEINE—See Caffeine and Tea.

THENARDITE (Na_2SO_4)—A mineral of crystal system, No. 4, and sp. gr 2·7. (See Sodium (Sulphate).)

THÉNARD'S BLUE—See Cobalt Blue.

THEOBROMINE ($C_7H_8N_4O_2$)—A white, crystalline, poisonous purine base of bitter taste, and m.p. 329° C., being the active principle of cacao beans, and nearly allied in chemical constitution to caffeine, which can be produced from it by replacing an atom of hydrogen with the radical methyl. The content varies with the different types from about 1 to 1·7 per cent. of the shelled beans, or 2·2 to 3·9 per cent. of the dried fat-free material, while the germ, as separated commercially, contains about 2·1 per cent. It is soluble in chloroform, but not in water or alcohol. (See Cacao.)

THEORY—A reasonable view of ascertained facts, or a philosophical explanation of known phenomena not so conjectural as an hypothesis.

THERM—The name given by Parliament to 100,000 British thermal heat units (B.Th.U.) as the basis of coal-gas charges. The therms used are ascertained by multiplying the number of cubic feet consumed by the declared calorific value of the gas. A B.Th.U. is that required (absorbed) to raise 1 lb. water at its temperature of maximum density

THERM (*Continued*)—

1° F. = 250 gramme calories. The heat equivalent of a Board of Trade unit of electricity is 3,411 B.Th.U. (See Heat (p. 434) and Steam.)

THERMAL DISSOCIATION—A reversible chemical change brought about by heat. (See Dissociation.)

THERMAL EFFICIENCIES—See Steam.

THERMAL INSULATION—See Heat Insulation.

THERMAL STORAGE—See *Ind. Chem.*, 1930, vi., 63.

THERMAL UNIT—See Therm and Heat.

"THERMALINE"—A German mixture of calcium carbide and crude oil with sawdust, which, upon addition of water, yields a mixture of fuel gases, consisting of acetylene and the vapour generated by the burning crude oil. The mixed gases are claimed to show advantages as a fuel for certain high temperatures.

THERMIONIC VALVE, or three-electric vacuum tube, applicable to determination of the electrical conductivity of electrolytes or hydrogen-ion concentration, the velocity of gases, etc. (See W. Hiltern on the theory of these valves, *B.C.A.*, 1931, A, 1387.)

"THERMISILID" (Krupp's)—An alloy claimed to be able to resist the action of dilute sulphuric and hydrochloric and most organic acids.

"THERMITE" PROCESS—When a mixture of metallic aluminium powder and ferric oxide is subjected to ignition by a fuse or otherwise, the whole mass ("thermit") becomes incandescent, the aluminium combining with the oxygen of the iron oxide, and setting free the molten iron, which forms a layer below ($Fe_2O_3 + 2Al = Al_2O_3 + 2Fe$). The fuse may consist of a ribbon of magnesium terminating in a ball of barium peroxide and aluminium powder in contact with the mixture. The reaction is that of a system capable of undergoing a rapid exothermic chemical change of high velocity without evolution of gaseous products. The temperature realized is estimated at about 3,500° C., and being high enough to melt all known metals, the process is used as a welding application for the repair of broken castings and joining up the ends of tramway rails without removal. For this latter purpose, a mould is placed round the rail-ends so as to receive a charge of the molten iron, the excess metal being afterwards cut away or otherwise removed. This process is also used for making carbon-free metals and various alloys, including ferro-chrome, metallic chromium, metallic manganese, manganese-copper, manganese-zinc, and ferro-titanium; it was also applied in making incendiary bombs during the Great War.

Steel used for welding in chemical and process industries should have a carbon content below 0·25 per cent. as being the most easily handled. According to Schonlejkin and X. Solovovo, with ordinary iron thermit the heat radiation, as determined by a solarimeter, gives a maximal effect amounting to 38 kw., and with manganese dioxide and potassium permanganate the values are respectively 256 and 2,080 kw. (*B.C.A.*, 1930, B, 951).

THERMO-CHEMISTRY deals with the thermal changes involved in chemical interactions. (See *Thermometric Conversion Chart*, by P. L. Marks (Crosby Lockwood and Co.); also Chemical Interactions, Force (p. 368), and Heat.)

THERMO-DYNAMICS—The relationships between heat and work. (See *Chemical Thermodynamics*, by J. R. Partington (Constable and Co., Ltd., London), and book by F. H. Macdougal (Chapman and Hall).

THERMO-ELECTROMOTIVE FORCE—That arising from a temperature difference at the junction of two metals, as employed in a thermopile. (See Electricity (pp. 289 and 298) and Pyrometers.)

"THERMOLENE"—A quick-drying spirit (gum) cold lacquer for small articles, especially brass-ware, made in colourless or coloured forms.

THERMOLYSIS—A term sometimes used to express dissociation of chemical compounds by the agency of heat. (See Dissociation.)

THERMOMETERS—Instruments used to ascertain or register temperatures, constructed upon the principle of the expansion of fluids by heat, mercury being usually employed, and alcohol for low temperatures. Distance thermometers are made which give accurate readings up to 500° C. with the dial distant from the mercury bulb up to 150 feet. A low-temperature thermometer for use between the b.p. of liquid air and zero is described (in abstract) in the *Analyst*, 1925, **50**, 526.

A high-temperature thermometer, giving direct readings up to 1,000° C., has been produced by S. Boyer of the Research Laboratory, General Electric Company, Mass., using pure gallium as the filling liquid, and quartz capillary tubing of uniform bore. (See *Analyst*, 1926, **51**, 110.)

Messrs. Negretti and Zambra publish a list giving technical descriptions and information concerning electrical thermometers covering all temperatures between 270° and 3,000° F. The Cambridge Instrument Company also make a variety, including a quick-acting electrical thermometer, illustrated in the *Ind. Chem.*, 1931, vii., 173. (See Heat (p. 437) and Pyrometers.)

THERMOPILE (Thermo-Couple)—See Electricity (p. 298) and Pyrometers.

THERMOS VESSELS—See Vacuum.

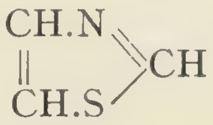
THERMOSTATS—Apparatus designed to maintain a constant temperature based upon the unequal expansion of different metals, liquids, or gases by the agency of heat. The simplest form is that of a water-bath heated by a gas lamp, together with a device for automatically controlling the supply of gas to the burner, so that the temperature of the water is kept constant. An automatic low-temperature thermostat is referred to by Mass and Barnes (*Analyst*, 1927, **52**, 252); one specially advantageous for use at from $-40°$ to $+20°$ (V. Cupr, *B.C.A.*, 1928, A, 1348); one for temperature range from 50° to 112° abs., by W. Justi (*B.C.A.*, 1931, A, 815); one for 20° to 1,000° by H. Bruning (*B.C.A.*, 1932, B, 245); another described by Egerton and Ubbelohyde (*B.C.A.*, 1930, A, 729); a simple electrically controlled one by J. A. Cranston

THERMOSTATS (*Continued*)—

(*J.C.S.*, 1930, p. 1459); an electrically controlled steam-heated one by Cremer and Hawes (*Chem. and Ind.*, 1930, **49**, 511); an air thermostat for quantitative laboratory work by W. H. J. Vernon (*Trans. Faraday Soc.*, No. 121, Vol. xxvii., Part 6, June, 1931); a laboratory one for continuous operation (P. W. Schenk, *B.C.A.*, 1931, A, 457); one for use in corrosion research by U. R. Evans (*Chem. and Ind.*, 1931, **50**, 66); "An Air Thermo-regulator," by Coppock, Colvin, and Hume (*Chem. and Ind.*, 1932, **51**, 140); the Hopkinson "R" type automatic thermostatic regulators (Hopkinsons, Ltd., Huddersfield).

"THERMOTYME"—See Clays, p. 200.

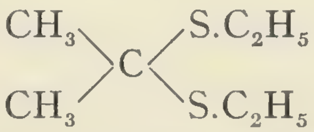
THIAZOLE—An organic colourless liquid, b.p. 117° C., derived from thiophene (a heterocyclic sulphur compound), represented by the formula:



THINNERS—See Paints.

THIO—A prefix used in respect of certain compounds in which oxygen is replaced by sulphur; also in some cases where sulphur replaces hydrogen in compounds in which the sulphur serves as a link, as in thioalcohols, thiobisaniline, etc.

THIOACETALS—Sulphur compounds analogous to the acetals, such as acetone ethyl mercaptol:



THIO-ACIDS (Sulpho-Acids)—Compounds containing the group—CO.SH, analogous to oxy-acids in which the oxygen is replaced by sulphur. (See Nomenclature and Oxy-acids.)

THIO-ALCOHOLS—See Mercaptans.

THIOCARBAMIDE (Thiourea) (CH_4N_2S)—A white crystalline substance, soluble in water and alcohol, of m.p. 172° C., made by heating dry ammonium sulphocyanate at 130° C. ($N.C.SNH_4 = CH_4N_2S$), or by the action of hydrogen sulphide on cyanamide ($CN.NH_2 + H_2S = CS(NH_2)_2$); used in photography and manufacture of "Beatl." (See *C.T.J.*, 1931, **89**, 427.)

THIOCARBANILIDE (Diphenyl Thiourea) ($CS(NHC_6H_5)_2$)—A colourless crystalline substance prepared by interaction of carbon disulphide aniline; sp. gr. 1·3205, m.p. 154° C.; soluble in alcohol and ether; used in organic synthetical processes and as a flotation reagent.

THIOCARBONYL CHLORIDE (Thiophosgene) ($CSCl_2$)—Prepared by the action of chlorine on carbon disulphide followed by steam distillation; a red, mobile, fuming liquid of irritating odour resembling phosgene in chemical characters; used in the dyestuffs industry.

THIOCOLL—Potassium guaiacol—3—sulphonate $OH.C_6H_3(OCH_3)SO_3K$, used in medicine for same applications as guaiacol, being less irritant.

THIOCYANIDES (**Thiocyanates**) are combinations of bases with thiocyanic acid ($HCNS$). By fusion of sulphur with potassium cyanide or sodium cyanide the corresponding potassium sulphocyanide ($KCNS$) and sodium sulphocyanide ($NaCNS$) are formed. They are readily soluble in water, are not poisonous, and are used in the textile trade, in black nickel-plating, photography, dyeing, and calico-printing.

Mercury sulphocyanide is used in making so-called "Pharaoh's serpents," owing to the fact that when heated it swells, grows in fantastic form to great size, and retains the resulting formation.

Thiocyanides result from the action of free thiocyanogen upon various metals, and can be prepared from the ammoniacal liquor of gasworks. (See Gas (Coal).)

THIOCYANOGEN, $(SCN)_2$, is a viscid, unstable, yellow oil, obtained by action of bromine dissolved in carbon disulphide, or a tetrachloride solution, upon a metallic thiocyanate, such as silver, lead, or mercury, and evaporation of the solution *in vacuo* ($2MSCN + Br_2 = 2MBr + 2SCN$). When a solution of thiocyanogen in carbon disulphide is cooled to $-70°$, the body is stated to separate in crystalline form. It can also be produced by the electrolysis of alkali thiocyanates in aqueous or alcoholic solution. It yields organic thiocyanates by combination with such groups as methyl, and has been advocated for use in volumetric analysis, a solution in acetic acid having been employed for "rhodanometric" determinations of the iodine values of fats and oils. (See H. P. Kaufmann, *B.C.A.*, 1926, B, 165.)

THIOLS—See Mercaptans.

THIONIC ACIDS—See Sulphur (Oxides).

THIOPHENE (C_4H_4S)—A constituent of coal tar (b.p. 84° C. and freezing-point $-37{\cdot}1°$ C.), having a faint odour resembling benzene, nearly always found in small proportion in commercial benzene and obtainable by interaction of acetylene and sulphur vapour. (See Briscoe (with others) (*B.C.A.*, 1929, A, 73) and Flury and Zernik (*Analyst*, 1932, **57,** 262).)

THIOPHENOLS—Phenols in which the hydroxyl oxygen is replaced by sulphur, such as thiophenol (phenyl mercaptan) (C_6H_5HS).

THIOUREA—See Thiocarbamide.

THISTLE-FUNNEL—A narrow glass tube with small funnel-head by means of which a liquid can be conveyed into any vessel with which it may be connected.

THOMSONITE—One of a series of minerals (crystal system, No. 4, and sp. gr. about 2·3) which may be viewed as mixed crystals of the end members $CaO,Al_2O_3,2SiO_2,3H_2O$ (calcio-thomsonite) and natrolite. (See *J.C.S. Abs.*, II., cxxvi., 868.)

THORIANITE (ThO_2)—A heavy black mineral containing a large proportion of thoria mixed with uranium oxides, etc., found in Ceylon and Montana. It usually occurs in small cubes, and has a sp. gr. of 9·5.

THORITE—A mineral consisting essentially of silicate of thorium, yellow to dark brown in colour, of crystal system, No. 2, and sp. gr. 4·4 to 5·4; found in Ceylon and Norway.

THORIUM (Th) **and its Compounds**—Atomic weight, 232·15; sp. gr. about 11; m.p. not definitely ascertained, but about 1,690° C. It is a rare metal occurring in the minerals *carnotite, thorite, thorianite, orangite,* and *monazite.* In the form of oxide (as obtained from the nitrate by combustion, and fusible at a temperature of about 3,540° C.) it is used in the preparation of incandescent gas mantles. The purer thorium compounds are worked up from monazite sand, which is essentially a phosphate of the cerium earths and occurs naturally in extensive deposits in Carolina, the coast of Brazil, and Travancore. The separated monazite from the Travancore deposits contains about 8½ per cent. of thoria, as compared with 6 per cent. in the best concentrates from the Brazilian sands. The process of its extraction from ores and other particulars are given in an article by C. M. Dyson (*Ind. Chem.,* 1931, vii., 231).

Thorium can be obtained by heating the double chloride of thorium and potassium with metallic sodium, and as thus produced is a grey, dense, almost infusible powder. Obtained as a deposited layer by passing the vapour of the iodide over a heated tungsten filament, it is described as of ductile character. (See van Arkel and de Boer, *B.C.A.,* 1925, **44,** B, 994.)

It is soluble in dilute hydrochloric and sulphuric acids, and is known in both crystalline and amorphous forms. Two oxides (ThO_2 and Th_2O_7) insoluble in water are known, and the dioxide exercises a promoting action on nickel catalysts. The chloride ($ThCl_4$) and the white crystalline nitrate ($Th(NO_3)_4 12H_2O$) are soluble in water; there are also other compounds, which generally resemble those of cerium.

Meso-Thorium (described as one of ten radio-active disintegration products of thorium) exhibits properties similar to those of radium, for which it is used as a substitute. It is a regular by-product of the manufacture of gas mantles from monazite sand, is employed medicinally, and is specially adapted for making luminous paint by admixture with zinc sulphide, particularly in respect of articles required for comparatively short periods. (See Gas Mantles, Ionium, and Monazite.)

THUJA OIL—Distilled from the leaves of the white cedar or common Arbor Vitæ (*Thuja occidentalis*), containing *d*-pinene, *l*-fenchone, and thujone; sp. gr. 0·915 to 0·925; of agreeable odour, pale yellow in colour, soluble in alcohol, ether, etc., and used in medicine as a vermifuge. (See Rutovski and Gusseva, *B.C.A.,* 1929, B, 537.)

THUJENE ($C_{10}H_{16}$)—A hydrocarbon which can be prepared from sabinol by hydrogenation, also from thuja oil; b.p. 151° to 152°. (See Sabinene and Savin Oil.)

THUJONE ($C_{10}H_{16}O$)—A ketone contained in thuja oil and the oils of sage, tansy, and wormwood; convertible into carvacrol.

THULIUM (Tm)—Atomic weight 169·4. A rare element of the yttrium group identified by its spectrum, and found in association with yttria

THULIUM (*Continued*)—
in a number of minerals, including *gadolinite, keilhanite, euxenite,* and *samarskite.*

THYME OIL—The red variety of thyme oil is obtained from garden thyme (*Thymus vulgaris* L., N.O. Labiatæ) by distillation with water, a pound yielding from 20 to 90 grains of oil, soluble in alcohol, ether, etc. It contains from 25 to 45 per cent. phenols, including carvacrol ($C_{10}H_{14}O$), which is isomeric with thymol, but, according to some statements, no thymol, while an account by F. La Face (*J.C.S. Abs.*, cxxviii., I., 564) describes a sample containing 20·5 per cent. phenols, of which 95 per cent. is thymol. (See also Rutovski and Vinogradova, *B.C.A.*, 1929, B, 910.) It has a pleasant odour and camphoraceous taste; sp. gr. 0·9 to 0·95 at 15° C., opt. rot. 0° to 4° at 20° C., and ref. ind. 1·480 to 1·498 at 20° C.

Wild thyme which contains the same essential oil is *T. serpyllum.*

The richest oils are distilled from the Andalusian *Thymus Zygis* and *Corydothymus capitatus,* the phenols ranging from 35 to upwards of 67 per cent. in the last named.

The genuine thyme or origanum oil from Trieste, Cyprus, and Smyrna is stated to contain 50 per cent. thymol and upwards, associated with a terpene named thymene ($C_{10}H_{16}$) and cymene ($C_{10}H_{14}$). It possesses strong antiseptic properties, is soluble in alcohol, and is used in perfumery and for flavouring. Its sp. gr. is 0·915 to 0·98 and opt. rot. 0° to 13°. (See E. Puxedda (*B.C.A.*, 1926, B, 930), and Thymol.)

THYMOL ($C_{10}H_{14}O$), a homologue of phenol (m.p. 49° C., and b.p. 232° C.), is a white crystalline substance of mild, pleasant odour found present in origanum oil, also in horsemint, monarda, and ajowan oils. It is but slightly soluble in water, dissolves readily in alcohol and ether, and is a valuable antiseptic, anthelmintic and preservative, finding special use as a drug in cases of hook-worm. Recent chemical investigations appear to indicate that the best source of thymol in the future will be the ketone named piperitone, which is contained in the oil yielded by the *Eucalyptus dives* and *E. piperita*, and from which it is now made to some extent. It can also be made synthetically from cymene. Thymol is said to be the chief product when *m*-cresol and isopropyl alcohol are condensed by the aid of phosphoric acid at 70° to 80° C. (See Bert and Dorien, *B.C.A.*, 1926, A, 164.)

When piperitone is oxidized by ferric chloride and acetic acid, using manganese salt as catalyst, it gives a yield of from 48 to 53 per cent. thymol, and when reduced by hydrogen in presence of nickel at 175° to 180° C. it gives an almost quantitative yield of menthone, readily convertible into menthol by treatment with sodium in aqueous ether. (See S. Kimura, *B.C.A.*, 1930, A, 1294.)

The percentages of thymol in various essential oils have been reported as follows:

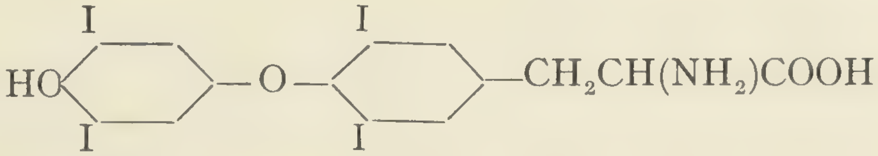
THYMOL (*Continued*)—

Ajowan oil	40 to 50
Thymus vulgaris	20 to 30
Monarda punctata	60
Carum copticum	45 to 55
Ocimum viride	37
Origanum hirtum from Crete and Dalmatia	60 to 67
Mosla japonica	44
Wild thyme of France	20

(See Ajowan Oil.)

THYROXIN—

$(C_{15}H_{11}NO_4I_4)$ or



—The essential hormone constituent of the thyroid gland, being an iodine compound used in medicine. It has been isolated in a crystalline state, and is capable of removing the condition of myxœdema or cretinism—that is, the retardation of oxidative metabolism causing stunted deformed growth. It affects mental behaviour and causes rapid disappearance of stored sugar by inducing an increase in the metabolic rate. It was synthesized by C. R. Harrington, and is now manufactured by a number of steps from quinol and *p*-nitroaniline. (See C. R. Harrington (*Chem. and Ind.*, 1926, **45**, 482); Harrington and Barger (*Chem. and Ind.*, 1926, **45**, 931); Harrington and Barger (*B.C.A.*, 1927, A, 358); Harrington and McCartney (*J.C.S.*, 1929, p. 892); A. J. Clark (*Inst. Chem. J.*, 1930, part 2, p. 108); and book on *Thyroxine*, by E. C. Kendall (by whom it was first prepared), Amer. Chem. Soc. Monograph Series (Chem. Catalog. Co., N.Y.).)

"TILLET"—A protective coating containing rubber and oxidized bitumen dissolved in benzol.

TIMBER—See Wood.

TIME CHECKING—Various recorders are made, including that known as the "Gledhall-Brook."

"TIMONOX"—A proprietary brand of a white oxide of antimony, claimed to possess the essential requirements of a first-class pigment, having good oil absorption, good covering power, great opacity, perfect freedom from crystals, and easily ground with oil. It is also used in the enamel industry as an opacifier.

TIN (Stannum, Sn) **and its Compounds**—Atomic weight 118·7; sp. gr. 7·29; m.p. 231·9° C.; credited with twelve isotopes. Tin is found in nature for the most part in the form of oxide (SnO_2) in the mineral known as *tin-stone* (*cassiterite*) in Cornwall, the production in that county in 1890 amounting to 15,000 tons, but only to 6,378 tons in 1918; it also occurs in Australia, Bolivia, Burma, Canada, Nigeria, and Mexico, but the Malay States is the chief producer, the world production being roughly estimated at 130,000 tons per annum, and the British

TIN (*Continued*)—

share some 40 per cent. of the total. The metal is ordinarily prepared from it (or from gravel of poorer character obtained by a dredging process), after washing, by calcination, whereby the oxygen constituent is removed as carbon monoxide, the associated sulphur and arsenic are burnt off as sulphur dioxide and arsenious oxide, while any metallic iron and copper are oxidized. The residue is washed, thereby dissolving any copper sulphate produced in the calcination, and the lighter associated matters including the iron oxide are removed. The heavier purified ore is then reduced by smelting with anthracite in a reverberatory furnace ($SnO_2 + 2C = Sn + 2CO$), and the resulting metal further purified by heating in another furnace with green wood until the tin melts and flows away as block tin from associated alloys and the dross.

The process of electrolytic tin refining, as carried on at Perth Amboy (U.S.A.), is described by J. R. Stack (*C.T.J.*, 1924, **74**, 558; "The Effect of Impurities on the Properties of Tin," by P. G. J. Goeterbock and G. N. Nicklin (*J.S.C.I.*, 1925, **44**, 370 T); see also *C.T.J.*, 1928, **83**, 186, on "Tin Smelting in the United Kingdom"; and *Tin: its Mining, Production, Technology, and Applications*, by C. L. Mantell (Chem. Catalog. Co., Inc., N.Y.).

"Chempur Tin" is a specially refined Straits Settlements product, said to contain less than one-twelfth of the impurities ordinarily occurring in the "Straits" tin.

Tin is a bright white metal obtainable in crystalline form, and does not tarnish in the air; is fairly soft, ductile, of poor electric conductivity, and malleable, but at 228° C. it becomes quite brittle. So-called "grey tin," resulting from exposure of the white metal to a temperature below 13° C., has a sp. gr. of 5·8, and is an allotropic form, as it loses its largely increased volume and is reconverted into the white form again on raising the temperature to above 13° C. As to the alleged allotropy of tin in three forms of varying densities, see A. Travers and Huot (*B.C.A.*, 1927, A, 194).

A very small percentage of aluminium is sufficient to make tinfoil brittle in a short time.

Many chemical methods have been advocated and used for the recovery of tin from waste materials, including the use of chlorinated carbon tetrachloride and subsequent distillation of the solvent from any stannic chloride thus obtained; others for dissolving the tin and extraction of the metal from the resulting solution by treatment with an aluminium or zinc alloy; and many electrolytic processes, the general principle involved being the electrolysis of the metallic waste products in an alkaline or acid solution. (See A. C. Hopper (*C.T.J.*, 1925, **77**, 503) and J. B. C. Kershaw (*Ind. Chem.*, 1926, ii., 488).) A process using a dilute solution of tartaric acid as the solvent of the tin in the presence of air is described (*Ind. Eng. Chem.*, 1930, p. 910).

The metal dissolves in cold dilute nitric acid, stannous nitrate being formed ($4Sn + 9HNO_3 = 4Sn(NO_3)_2 + 3H_2O + NH_3$), while stannous chloride is formed by the action of strong hydrochloric acid.

Tin is largely used in the process of tinning iron and other metals

TIN (*Continued*)—

and making metal joints. Ordinary tinplate consists of very mild steel containing about 0·1 per cent. carbon, coated with tin on the surface by dipping into a bath of the molten metal. The plates are first of all "black pickled" by moving them about in hot, weak (7 per cent.) sulphuric acid to remove oxide scale, washed, then piled up wet for "black annealing"—a process in which they are heated for ten to twelve hours in a furnace with a reducing flame—and, after rolling (during which they become hardened), they are "white pickled" in a weaker bath of acid; finally, they are passed through a strong solution of zinc chloride (which is used as a flux) and then into the molten tin. In its final stage the tinplate is passed through a bath of boiling hot palm oil. A variety of tinplates of inferior character known as "terneplates" are coated with lead or with an alloy of tin and lead of varying composition—viz., 1 lead and 2 tin or 2 lead and 1 tin. (See C. A. Edwards on the chemical aspects of tinplate making (*Chem. and Ind.*, 1929, **48,** 241); accounts of the industry, by E. W. Lewis (*Ind. Chem.*, 1929, v., 379) and D. Griffiths (*Chem. and Ind.*, 1931, **50,** 431); J. Jones on "Mottled Tinplates" (*B.C.A.*, 1931, B, 1013); and Food Investigation Report No. 40, 315, on Corrosion of Tinplate Containers.)

According to Sir T. Legge's account of the process of tinning hollow ware, iron articles are cleaned by immersion in a tank of hot dilute hydrochloric acid, then dipped into a cold weak acid solution of zinc chloride, and subsequently immersed in a molten bath of 40 per cent. tin and 60 per cent. lead, the excess of metal on the articles being afterwards wiped off, using a pad of tow held by the worker's hand for that purpose. The cases of poisoning to which this process gives rise is due to escaping vapours of the chlorides of lead, zinc, and tin into the air. Methods of avoiding such poisoning are also dealt with in Legge's lecture (published by the Inst. of Chem., 1930).

"Chemical tinning" is effected by immersion of the subject articles in a solution compounded of cream of tartar, ammonium alum, and stannous chloride at about 180° to 190° T. "Cold tinning" is carried out by cleaning the article with strong hydrochloric acid, application of a soft amalgam of tin, and distilling off the mercury by heat.

Pure tin has valuable applications by reason of the fact that it is innocuous when used for the preservation of foods, and is not acted upon by many chemicals which attack iron and some other metals; it also enters into the composition of many alloys, including solder, brasses, Britannia metal, bronzes, "magnolia," and pewter.

The analysis of the British chemical standard tin-base white metal B is as follows: tin, 84·0 per cent.; antimony, 7·52 per cent.; copper, 4·03 per cent.; lead, 3·86 per cent.; zinc, 0·40 per cent.; iron, 0·05 per cent.; and arsenic, 0·04 per cent.

Tin Oxides—When strongly heated in the air, tin takes fire and forms stannic oxide (SnO_2), a white, insoluble, amorphous substance which turns yellow on heating, is not acted upon by acids or alkalies, and is used in making "putty powder"; also as a polishing-powder for

TIN (*Continued*)—

steel and glass, and in the manufacture of certain kinds of glass. The stannous oxide (SnO) can be prepared by heating the oxalate out of contact with air, or in hydrated form ($3SnO,2H_2O$) by adding a solution of sodium carbonate to one of stannous chloride. It is soluble in acids, forming stannous salts, and when heated in the air it becomes peroxidized to SnO_2. The hydroxide dissolved in sodium hydroxide is used by calico printers under the name of "sodium stannite."

Stannic Acid (H_2SnO_3) is obtained in hydrated form by adding a solution of calcium carbonate to one of stannic chloride in insufficient quantity for complete precipitation, and, as thus produced, is a white gelatinous body insoluble in water, capable of forming a number of salts, including potassium and sodium stannates, which are soluble in water, the last named being used as a mordant under the name of "tin preparing salt" ($Na_2SnO_33H_2O$), and made, amongst other methods, by fusing metastannic acid with sodium hydroxide.

Metastannic Acid ($H_{10}Sn_5O_{15}$)—A white powder obtained by the action of strong nitric acid upon tin.

Stannous Chloride ($SnCl_22H_2O$), a white, crystalline body, soluble in water, obtained by dissolving tin in hydrochloric acid; used in ink-making, also as so-called "tin salts" and "tin crystals" by calico printers and dyers and in tin galvanizing. It can be obtained in the anhydrous state by treatment with acetic anhydride. (H. Stephen, *J.C.S.*, 1930, p. 2786.)

Stannic Chloride ($SnCl_4$) is obtained by the action of chlorine gas on the metal, also by passing chlorine in excess through a solution of stannous chloride. In the pure anhydrous state it is a colourless liquid which boils at 120° C., fumes in the air, and forms several hydrates with water. One of these—viz., $SnCl_45H_2O$—is crystalline, soluble in water, and is used as a mordant; but for that purpose it is more usually prepared by dissolving tin in cold aqua regia, when it is commercially known as "oxymuriate of tin," and is used also for weighting silk and in tinning of vessels, etc.

Stannous Chromate ($SnCrO_4$)—A brown substance, insoluble in water, used in decorating porcelain.

Stannous Sulphate ($SnSO_4$)—A heavy, white, crystalline powder, soluble in water, used in dyeing and electroplating. According to Mathers and Rothrock, 15 parts of tinfoil or of electro-deposited tin in a spongy condition dissolves readily in 40 parts of 75 per cent. sulphuric acid working with a final temperature of 140° C., yielding stannous sulphate free from stannic sulphate. (Note in *C.T.J.*, 1931, **88,** 383.)

Stannous Oxalate (SnC_2O_4)—A heavy, white, crystalline powder, obtained by the action of oxalic acid upon tin, or stannous oxide; soluble in acids, and used in dyeing and printing textiles.

Stannous Sulphide (SnS)—A leaden-coloured substance formed when tinfoil is introduced into the vapour of sulphur, the metal taking fire in

TIN (*Continued*)—

the reaction. In hydrated form it is produced by passage of hydrogen sulphide gas into a stannous solution.

Stannic Chromate ($Sn(CrO_4)_2$) is brown, soluble in water, and used in decorating porcelain.

Stannic Sulphide (SnS_2) is a bright yellow crystalline powder used as a pigment for imitation-gilding under the name of "mosaic gold," and is obtained as the result of complicated changes by heating tin amalgam together with sulphur and ammonium chloride. It is soluble in alkaline sulphide solutions, and can be sublimed to some extent. (For details concerning the preparation and applications of mosaic gold see Hans Hadert, *C.T.J.*, 1926, **78**, 32.)

Stannous Tartrate ($SnC_4H_4O_6$) is a heavy, white, crystalline substance, soluble in water, used in the textile industries.

Stannic Phosphide (Sn_2P_2), a silver-white compound made by heating the metal with phosphorus; used in making phosphor-bronze.

Stannous hydride (SnH_2) and stannic hydride (SnH_4) are poisonous gases, and there are a number of organo-metallic compounds of tin; among them, tin tetraethyl ($Sn(C_2H_5)_4$), tin dimethyl ($Sn(CH_3)_4$), methyl-stannonic acid ($CH_3.SnO.OH$), and some acyl derivatives. (See also Purple of Cassius.)

TIN CRYSTALS—See Tin Compounds (Stannous Chloride).

TIN PREPARING SALT—See Tin Compounds (Stannic Acid).

TINCAL—See Boron.

TINCTURES—Alcoholic solutions of drugs; more dilute than extracts. (See Extracts.)

TINPLATE—See Tin.

TIN-STONE—See Tin.

TINTOMETERS—See W. D. Hutchins (*Analyst*, 1931, **56**, 693), and Colorimeters.

TITANITE (CAO,TiO_2,SiO_2)—A mineral of crystal system, No. 5, and sp. gr. about 3·5. (See Titanium.)

TITANIUM (Ti) **and its Compounds**—Atomic weight 47·90 with isotope 48 mass number; sp. gr. variously given as 4·5 and 4·87; m.p. 1·800° C. This element occurs plentifully in several mineral forms—viz., as oxide (TiO_2) in *anastase, brookite,* and *rutile,* and in other forms in *ilmenite, titanite,* and *titano-columbates,* although there are no large deposits in this country. It is also found present in Nile silt, and finds some employment in metallurgy. Deposits of *rutile* exist in Norway, Georgia, Virginia, Tasmania, and Australia, and are marketed in the form of black concentrates containing from 93 to 98 per cent.

Ilmenite ($FeTiO_3$) is found in Virginia, Florida, Tasmania, and Madagascar, but the largest deposits occur in Quebec and Norway; while a deposit associated with uranium exists at Olary in South Australia, and is used as a source of radium and titanium oxide.

Ilmenite, containing from about 34 to 44 per cent. TiO_2, is chiefly used in the manufacture of ferro-titanium alloys, arc-lamp electrodes,

TITANIUM (*Continued*)—
and titanium pigments; while *rutile* is chiefly used in the preparation of titanium compounds and sometimes to give a yellow colour to porcelain. (See Titanium Oxide Paints and "Titanox.")

Titanium is used in metallurgy chiefly as alloyed with other metals for a number of purposes, ferro-titanium alloys being used as deoxidizing agents and oxygen and nitrogen scavengers, a small quantity of titanium (which readily forms nitride) being of advantage for the final purification of nearly all grades of steel, while cupro-titanium and mangano-titanium alloys are used in brass and bronze practice. The nitride as now produced at Glendale, California, from *ilmenite* by the process represented as follows, $2(FeO,TiO_2) + 6C + N_2 \geqslant 2Fe + Ti_2N_2 + 6CO$, has found employment for giving a high resistance to foundry moulds and cores. (See *Chemical and Metallurgical Engineering*, December, 1926.)

Obtained as a thick layer by passing the vapour of the iodide over a filament of metallic tungsten, titanium has been described as a ductile metal. (See van Arkel and de Boer, *B.C.A.*, 1925, B, 994.) It is obtained as a dark grey, amorphous powder by heating titanous chloride with metallic sodium. It combines with oxygen at 500° C. with incandescence forming dioxide; decomposes water at 100° C.; dissolves in hydrofluoric and dilute sulphuric acids, also in aqua regia and hot strong hydrochloric acid; resembles tin in many of its properties, and forms two oxides (TiO and TiO_2), which are non-toxic, insoluble in water, and are used in the preparation of enamels to make them more resistant to corrosion.

A process under trial in Canada for producing titanium dioxide from *ilmenite* ores consists of heating them with carbon in a rotary kiln furnace and treating the product with ferric chloride, thus forming ferrous chloride and leaving an insoluble residue of titania, which is subsequently purified by conversion into sulphate, leaching with cold water, and hydrolysing the solutions, causing the precipitation of metatitanic acid (H_2TiO_3).

The dioxide has been used as a colouring agent in porcelain glazes, and it can be usefully employed in the manufacture of glasses of high heat-resisting and durable character by incorporating it to replace certain proportions of soda, their viscosity increasing proportionately.

Titanium and some of its compounds are also used in connection with incandescent lighting.

Titanic Acid (H_2TiO_3) is a white powder, insoluble in water, but soluble in mineral acids and alkalies, and used as a mordant in dyeing.

Titanous Chloride ($TiCl_3$) can be prepared, among other methods, in the form of violet crystals by reduction of the tetrachloride with hydrogen, and is used commercially in connection with the dyeing of cotton goods when "over-dyeing" has occurred and they require "stripping" before re-dyeing. There is also an oxychloride ($3TiCl_4, TiO_2$).

Titanium Oxalate ($Ti_2(C_2O_4)_3.10H_2O$) is a yellow, crystalline salt, soluble in water, used as a mordant in textile dyeing.

TITANIUM (*Continued*)—

Titanium Sulphates ($Ti_2(SO_4)_3$ and $Ti_2(SO_4)_2 9H_2O$) are white crystalline salts soluble in hot water and used as textile mordants.

Titanium Tetrachloride ($TiCl_4$), a colourless liquid of sp. gr. 4·59, soluble in water, made by heating the dioxide and carbon to redness in a current of chlorine, was used in the Great War for making smoke-screens; it is used for gas removal, grain refinement, and in association with potassium bitartrate as a mordant.

Titanium-potassium Oxalate ($TiO,C_2O_4,K_2C_2O_4,H_2O$), commercially known as "T.P.O.," is an important aid to the leather dyer and stainer, as it can be used as a fixing agent previous to dyeing with basic colours and in conjunction with acid colours, the colours so produced ranging from a bright yellowish-brown to a reddish-yellow.

Titanium-sodium sulphate ($Ti_2(SO_4)_3,Na_2SO_4 5H_2O$) and titanous sulpho-cyanide ($Ti(CNS)_3$) are used as mordants for cotton, wool, paper, etc.

TITANIUM OXIDE PAINTS—The growing importance of titanium dioxide as a pigment has led to a process being worked in Norway for the production of this compound on a considerable scale from *ilmenite* (titaniferous iron ore). It is obtained also to some extent as a by-product in the process for extracting aluminium from bauxite at Katin in India. As compared with white-lead and zinc oxide, "titanium white" (a combination of 26·5 per cent. titanium oxide and 73·5 per cent. barium sulphate) offers considerable advantages, possessing, it is said, a greater covering power, being non-poisonous, chemically inert, without saponifying action upon linseed oil, and does not blacken upon exposure. The most durable paint pigment would appear to be a mixture of 80 per cent. titanium white with 20 per cent. zinc oxide. The resinates and linoleates of cobalt and manganese are good siccatives for use with titanium paints (0·2 per cent. manganese or 0·03 per cent. cobalt).

Paints containing titanium pigments are described as elastic, and do not crack or scale after long weathering; moreover, the titanium pigments have a high covering and oil-absorption power. (See "Titanox.")

"Ready-to-use" paints are stated to be compounded of from 52 to 62 per cent. white titanium pigment, with from 48 to 38 per cent. oil respectively.

(See reference to the American production of titanium oxide pigments from *ilmenite* (*C.T.J.*, 1928, **83,** 102); a paper on "Titanium Oxide Pigments," by N. Heaton (*J.S.C.I.*, 1930, p. 143 T); its preparation from the nitride by the use of nitric acid and catalysts (*C.T.J.*, 1929, **85,** 486), and from the cyano-nitride by F. von Bichowsky (*Ind. Eng. Chem.*, 1929, **21,** 1061); and article by E. R. Youngman based upon the review of the titanium pigments industry by the U.S.A. Bureau of Mines (*C.T.J.*, 1931, **88,** 29).)

"TITANOX"—A pigment described as titanium dioxide precipitated upon a base of finely divided *blanc fixe*, nearly as white as "French-pro-

"TITANOX" (*Continued*)—
cess" zinc oxide, resistant to sunlight and to hydrogen sulphide. There are various grades, the dioxide content (TiO_2) varying from 25 to 35 per cent. A compound pigment of zinc oxide 30 per cent. and "titanox" 70 per cent. has proved good in exposure tests as regards cleanliness from dirt collection. (See H. A. Gardiner, *J.S.C.I.*, 1924, B, 303, and 1925, B, 641.)

TITRATION—See Reagents and Volumetric Analyses.

TOAD POISONS—See M. Kotake, *B.C.A.*, 1928, B, 1138.

TOBACCO—The tobacco plant, of which there are many species, belongs to the genus *Nicotiana* (N.O. Solanaceæ). It is grown in many countries, including Virginia and other southern states of America, Rhodesia, Nyasaland, Canada, Turkey, Greece, Bulgaria, Brazil, Mexico, Sumatra, Manila, and North Borneo, the U.S.A. being the largest producing country. The *N. tabacum* gives the American tobacco, the *N. rustica* yields the Turkish and other varieties, and the *N. persica* the Shiraz tobacco. From experiments made in Hampshire it would also appear that tobacco can be grown in this country to advantage. The quality of tobacco, as also the nicotine content, varies with climate and soil, so that the Turkey-grown product has an entirely different aroma from that grown from the same seed in California, while plants grown in Cuba and transplanted into Florida with Cuban soil around the roots mature with a different quality of leaf. Among other considerations, the ratio of ammonia, phosphoric acid, and potash in the fertilizer is of great importance.

It is alleged that the only practicable way of rendering the nicotine content of tobacco harmless without detracting from the aroma is by treatment with iron salts or certain organic acids which render the nicotine non-volatile (M. Popp).

There is no one special tobacco pest corresponding to the boll-weevil of cotton, but a long list of attacking insects, particularly the leaf-eating caterpillars, including noctuids such as *Prodenia* and *Heliothis*, the hawk-moth caterpillars of the genus *Protoparce*, the surface caterpillar group of the genera *Agrotis* and *Euxoa*, and the leaf-eating genus *Pathorimœa*—the only specialized tobacco pest. The dried fermented leaf is the special food of the world-wide pest, the tobacco beetle (*Lasioderma serricorne*). For the preservation of tobacco against mould spoilage, use is made of acetic acid, but steam sterilization is preferable. "Offal" tobacco is used for the extraction of nicotine for use in the preparation of sheep-dips, etc., and various substances are used for the purpose of de-naturing the offal, including asafœtida, sulphur, tar acids and oils, lamp-black, bone oil, etc. According to Gabel and Kiprianov, about 96 per cent. of the nicotine contained in tobacco dust can be extracted by kerosine at 80° C. (*B.C.A.*, 1929, B, 996). (See also C. H. Liffy (*Ind. Chem.*, 1925, i., 182); A. Schmuck (*B.C.A.*, 1926, A, 547; 1928, B, 690); N. A. Barbieri (*B.C.A.*, 1928, A, 1063), according to whom a glucoside named tabacin is the toxic principle of tobacco; A. Schmuck and Balalucha on the chemical composition of

TOBACCO (*Continued*)—

tobacco (*B.C.A.*, 1929, B, 737); Pyriki and Dittmar (*Analyst*, 1931, **56,** 407); "Curing of Yellow Tobacco," by Smirnov and Izvoschikov (*B.C.A.*, 1931, B, 456); Vickery and Pucher (*B.C.A.*, 1931, A, 1341); and "Chemistry of Tobacco and Manufactured Tobacco Products," by A. A. Schmuck (Krasnodar: State Inst. for Tobacco Investigations, 1930).) (See also Nicotine.)

TOBACCO-SEED OIL, from Kentucky tobacco, is reported to contain 37·68 per cent. fat, consisting of about 52·4 per cent. olein, 22·1 per cent. linolein, and 23·9 per cent. palmitin, and to have a sp. gr. at 15° C. of 0·9404, sap. v. 196, and i.v. 132·8.

Dalmatian tobacco-seeds are stated to yield 35·4 per cent. oil, of sp. gr. 0·9250 at 15° C., sap. v., 196·4, and i.v. 131·6.

Tobacco-seed oil resembles cotton-seed oil in many respects, and a quality of edible oil of good flavour may be prepared from it, 100 kg. yielding from 30 to 35 kg., the seed per acre averaging 1,000 to 1,200 kg. For some further details concerning Greek tobacco-seed oil, see *C.T.J.*, 1929, **85,** 441; and M. P. Piatnitzki (*B.C.A.*, 1930, B, 427).

TÔHAKU OIL, from the seeds of *Lindera obstirol,* found in Korea, is yellowish-brown in colour, of sp. gr. 0·9329, solidifying at −14·4° C.; sap. v. 263·8, and i.v. (Wijs) 70·82). It contains capric and lauric acids, and is used as hair-oil. It is stated to yield an unsaturated fatty acid (linderic acid) with an i.v. of 126·33 and sp. gr. at 15°/4° of 0·9246.

TOLIDINE ($C_{12}H_6(CH_3)_2(NH_2)_2$)—A colourless crystalline body of m.p. 128° C., soluble in alcohol and ether; prepared by reduction from orthonitrotoluene, and used in making the red substantive dye, benzopurpurine 4B.

TOLU—See Balsams.

TOLUENE or METHYL BENZENE (**Toluol**) (C_7H_8 or $C_6H_5CH_3$)—An aromatic hydrocarbon of sp. gr. 0·87 at 15° C., being a benzene derivative of b.p. 110·70° C.; fr.p. −95·1°, soluble in alcohol, ether, and benzene. It can be obtained as a fractional distillate from coal-tar light oil, or by heating toluic acid with lime, and from tolu resin by dry distillation. Oxidized by nitric acid or chromic anhydride, it yields benzoic acid. It finds use as a solvent, in perfumery, as an intermediate, and in the preparation of "T.N.T." explosive and dyestuffs. (See Coal (p. 208) and Explosives (p. 330).)

TOLUENE SULPHAMIDE ($CH_3C_6H_4SO_2NH_2$)—A white crystalline salt used in connection with the manufacture of saccharin.

TOLUENE SULPHOCHLORIDE ($CH_3C_6H_4SO_2Cl$)—The *para* variety is a crystalline body of m.p. 69° C. and b.p. 145° C., soluble in alcohol and ether, used for treating swollen cotton in the presence of indifferent solvents, in order to convert the external fibres into a resistant sulpho-ester or "immune yarn," which behaves chemically like acetyl silk with certain dyes.

TOLUIC ACIDS (*meta, ortho,* and *para* varieties) ($C_6H_4CH_3COOH$).

TOLUIDINE (C_7H_9N or $C_6H_4.CH_3.NH_2$) exists in three isomeric forms. The solid para compound is a white, lustrous substance (contained in

TOLUIDINE (*Continued*)—
commercial aniline), m.p. 45° C., from which many red and violet dyes are prepared. The ortho and meta compounds are liquids which boil at about 197·7° and 203·3° respectively. (See Evers and Strafford, *J.S.C.I.*, 1927, **46**, 114 T.)

TOLUOL (**Toluole**)—Commercial toluene, obtained from the distillation of coal tar; also found in certain natural petroleums, and produced by "cracking" mineral oils; used as a source for making benzyl alcohol. (See Coal, Toluene, and Petroleum.)

TOLUYL—The radical group $CH_3—C_6H_4.C:O—$ of the toluic acids.

TOLUYLENE DIAMINE (**Meta**) ($C_6H_3(CH_3)(NH_2)_2$)—A colourless, crystalline intermediate soluble in water and alcohol, of m.p. 99° C.

TOLYL—The monovalent group $CH_3.C_6H_4$—the radical of toluene.

TOMATO-SEED OIL, expressed from the dried seeds of the tomato (*Lycopersicum esculentum,* N.O. Solanaceæ), a native of S. America, particularly Peru, and cultivated in many countries; is yellow; sp. gr. 0·92, sap. v. 191·6, and i.v. 114; soluble in benzol and carbon disulphide, and used in soap-making.

"TONITE"—See Explosives.

TONKA-BEANS (**TONQUIN-BEANS**)—The fruit of *Dipterix odorata* and other species of the N.O. Papilionaceæ, indigenous in Guiana and recently introduced into Malaya, containing coumarin and other substances; used in perfumery and for flavouring foodstuffs, etc. The non-drying oil expressed from the seeds is of sp. gr. 0·878; m.p. 7·2° C.; sap. v. 198·5; i.v. (Wijs) 72·6; ref. ind. at 27° = 1·4680; acid v. 1·0; unsaponifiable 0·5 per cent. (See C. Georgi and Gunn Lay Teik (*J.S.C.I.*, 1931, **50,** 318 T); also Coumarin.)

TOPAZ—A hard, translucent, silicated, aluminous mineral containing fluorine in combination, occurring in gneiss or granite, and varying in composition from $(AlF)_2SiO_4$ to $(AlOH)_2SiO_4$, of crystal system, No. 4, and sp. gr. from 3·35 to 3·65; used for making gems. Varieties occur in Russia, U.S.A., this country, and many other parts of the world, but the best come from Brazil.

TORBANITES—Natural products resembling oil shale, the deposits varying in quality, some giving up to 96 gallons and others only 25 to 30 gallons per ton. Extensive deposits exist in Pictou County in Nova Scotia and in parts of Africa, while small deposits occur in Somerset and allied with certain English coal-beds, and yield from 60 to 80 gallons oil per ton. There is a plant at New Glasgow, N.S., for utilization of the local shale deposits, in which the rock is heated in an air-tight retort of Mr. J. Ginet's invention, and the resulting gases condensed, each ton of torbanite yielding from 40 to 60 gallons petroleum. (See P. Niemann (*B.C.A.*, 1931, B, 184); E. Neufeld on "Torbanite Carbonization" (*B.C.A.*, 1931, B, 1127); Petroleum, Shale, and Kukkersite.)

TORBERNITE—A rare mineral represented as $(CuO + 2U_2O_3)P_2O_5,8H_2O$, associated with pitch-blende, and a source of radium. (See Chalcolite.)

TORRICELLIAN VACUUM—Space above the mercury in a barometer.

TOURMALINE—Name of a group of rhombohedral double silicates of aluminium and other bases found in granite, gneiss, or mica-slate, the colours varying with composition. When a crystal (crystal system, No. 3, and sp. gr. about 3·0) of tourmaline is heated to about 150° C. it becomes strongly electrical. (See F. Machatski (*B.C.A.*, 1931, A, 550) as to its formula; and *B.C.A.*, 1931, A, 595.)

TOWER FILLINGS—Materials employed for packing gas-washing towers or scrubbers, such as coke, bricks, "Obsidianite," "Nori" ware, "Redac" packings, "Propellar" fillings, etc. (See "Acid-proof Packings for Absorption Towers," by C. H. Butcher (*Ind. Chem.*, 1928, iv., 446); "Some Further Data upon Tower Packings," by C. H. Butcher (*Ind. Chem.*, 1929, v., 455); J. Arnould (*B.C.A.*, 1929, B, 420); and Sulphuric Acid, p. 877.)

TOXALBUMINS—Products of protein origin distinct from ptomaines, including the poisons of snake bites and others of plant origin, such as abrin (poisonous principle of *Abrus precatorius*—jequirity) and ricin (poisonous ingredient of the castor-oil plant). (See Bacteria.)

TOXIC—Poisonous; property of toxins. (See Bacteria and Chemotherapy.)

TOXICOLOGY—See *Forensic Chemistry*, by A. Lucas (Ed. Arnold and Co., London); Biochemistry, Poisons, and Vaccines.

TOXINS (**TOXINES**)—Poisons produced by micro-organisms in living tissues; others found in dead bodies and putrid animal tissues; and some produced by certain plants, etc. Antitoxins and contra-toxins are immunizing (neutralizing) substances produced from the blood plasma by toxin injections derived from microbic cultivations, or definite chemical substances respectively, into the blood. (See F. H. Carr (*J.S.C.I.*, 1927, **46**, 263 T); Albumins, Bacteria, and Ptomaines.)

"T.P.O."—See Titanium-potassium Oxalate, p. 921.

TRADE (**Chemical**)—See Three Years' Trade Figures (Import and Export), compiled from Board of Trade Returns (*C.T.J.*, 1932, **90**, 54); review of the industry in 1931 (*Ind. Chem.*, 1932, viii., 3); and H. Lindsay on "Modern Trade Tendencies" (*Chem. and Ind.*, 1932, **51**, 107), and A. Proven (*Ibid.*, p. 148).

TRADE WASTE—See Sewage and Waste.

TRAGACANTH—See Gums and Resins, p. 428.

"TRAGASOL"—A tough jelly made from the carob bean. (See Locust Kernel and "Gum Tragon" (p. 428).)

TRANSFORMER (**ELECTRICAL**) **OILS**—See J. G. Ford (*B.C.A.*, 1927, B, 960), and Oils.

TRANSMUTATION—This term in its chemical sense, and apart from its use as applied in stereo-isomerism, means the radical change of one element into another. The radio-active degradation products referred to elsewhere may conceivably be either sub-atomics or enormously subdivided products of previously closely associated bodies. The entire conversion of a substantial quantity of one absolutely pure element into another, as also the converse change, must be effected to carry conviction of accomplished transmutation. The transmutation of mercury

TRANSMUTATION (*Continued*)—
into gold has been claimed and further indicated according to H. Nagoaka (*J.C.S. Abs.*, 1925, cxxviii., II., 1111), reasserted by F. Bernhardt (*B.C.A.*, 1927, A, 5) and by A. Gaschlev (*B.C.A.*, 1930, A, 720); and while the synthesis of gold is claimed to have been effected by M. Jollivet-Castelot (*Annales de Chimie Analytique*, July 15, 1928), the evidence is not satisfactory, and these claims have been definitely repudiated. (See *Nature*, 1928, cxiii., 84.) Gold is soluble in mercury, and it is difficult to effect complete separation. Miethe's claim for obtaining gold from mercury is covered by Brit. Patent No. 243,670, and is based upon the electric treatment of mercury—that is to say, in an arc when the current changes (see *B.C.A.*, 1926, A, 367); see also Atoms, Electrons, Elements, Isotopes, Mass-Spectrography, Matter, and Radio-activity.

TRANSPORT—See "Transport of Bulk Materials" (*Ind. Chem.*, 1931, vii., 443); "Road Transport for Heavy Loads" (*Chem. and Ind.*, 1932, **51**, 181, 206, and 224; *Transport and Handling of Mineral Acids*, by F. Hirsch (E. Benn, Ltd., London); and Chemical Plant.

TREACLE—See Molasses.

TRIACETIN (**Glyceryl Triacetate**) ($C_3H_5(CH_3COO)_3$)—A narcotic poisonous glyceride prepared by heating glycerol with acetic anhydride alone or in presence of finely divided hydrogen-potassium-sulphate; sp. gr. 1·1603 at 15° C., b.p. 258° C., miscible with alcohol, ether, chloroform, and benzene. It is used as a plasticizer, also for gelatinizing and lowering the freezing-point of nitro-glycerine. (See Acetin.)

TRIADS—See Valencies.

TRIAMINES—Compounds containing three amino (—NH_2) groups (See Amines.)

TRIBASIC—See Basicity and Valencies.

TRIBASIC SODIUM PHOSPHATE—See Sodium Compounds, p. 833.

TRICHLORACETIC ACID (CCl_3COOH)—A deliquescent, colourless, crystalline compound of m.p. 57·3° C. and b.p. 195° C., made by the action of chlorine upon glacial acetic acid; used in medicine and for removing corns and warts.

TRICHLORETHYLENE (C_2HCl_3), of sp. gr. 1·47 and b.p. 85° C., can be made from tetrachlorethane by action of lime, and yields a very pure monochloracetic acid by decomposition with sulphuric acid, suitable for use in the production of synthetic indigo. It is non-inflammable, and used as a solvent in preference to carbon tetrachloride by seed extractors. (See Ethylene Dichloride, Solvents, and Westrosol.)

"TRICRESYL PHOSPHATE" ($PO(OC_7H_7)_3$)—The clear, colourless, liquid, commercial ester, used as a plasticizer for cellulose nitrate, is a mixture of isomers having a sp. gr. 1·177 to 1·180, boiling range 430°/440° C., flash-point 215° C., and ref. ind. at 20° 1·561 to 1·562; soluble in amyl acetate, acetone, benzene, etc. It is only sparingly soluble in gas-liquor and has been found to present advantages over benzene for the extraction of phenol. A given quantity will extract

"TRICRESYL PHOSPHATE" (*Continued*)—
from 10 to 20 times as much as benzene and owing to the high b.p. of the solvent, the recovery of the phenol is much simpler, it being merely necessary to distil it off, rendering the tricresyl phosphate ready for use over again. The tri-*o*-compound is a solid of m.p. 18° C. and sp. gr. 1·185 to 1·189 at 15° C.; the tri-*m*-compound is a liquid of sp. gr. 1·178 at 15° C.; the tri-*p*-cresyl phosphate is described as a crystalline solid of m.p. 76° to 78° C. (See *Pyroxylin Enamels and Lacquers*, by S. P. Wilson (Constable and Co.).)

TRIDYMITE—A rare, very hard, mineral form of crystalline silica of sp. gr. about 2·25, frequently occurring in volcanic rocks. (See Silicon.)

"TRIELINE"—See Solvents.

TRI-ETHANOLAMINE ($N(C_2H_4OH)_3$)—A clear, viscous, hygroscopic liquid of sp. gr. 1·124 at 20° C., mildly alkaline character, used as an emulsifier of oils, etc., in the preparation of cleansing soaps, the manufacture of synthetic resins, and as a gas absorbent. (See *C.T.J.*, 1928, **83**, 165, and 1930, **87**, 60.)

TRI-ETHYLAMINE [$(C_2H_5)_3N$]—An oily alkaline liquid. (See Amines.)

TRI-GLYCERIDES—See Fats.

TRI-METHYLAMINE [$(CH_3)_3N$]—See Amines.

TRI-METHYLENE GLYCOL ($OH.CH_2.CH_2.CH_2.OH$)—See Glycerol, p. 414.

TRI-NITRO-GLYCERINE—See Explosives and *Ind. Chem.*, 1927, iii., 302.

TRI-NITRO-TOLUOL—See Explosives.

TRI-OLEIN—See Fats.

TRIONAL or METHYL SULPHONAL ($C_8H_{18}S_2O_4$ or $CH_3(C_2H_5)C(SO_2C_2H_5)_2$)—A crystalline soporific and hypnotic, soluble in water, alcohol, and ether; m.p. 76·5° C.

TRI-PALMITIN—See Fats and Palmitin.

TRI-PHENYL METHANE ($CH(C_6H_5)_3$) is a colourless crystalline substance, m.p. 93° C., b.p. 359° C.; readily soluble in hot alcohol, ether, and benzene. Its derivatives include the malachite green, rosaniline, aurine, and the eosin groups of dyes.

TRI-PHENYL PHOSPHATE ($(C_6H_5)_3PO_4$ or $PO(OC_6H_5)_3$)—A colourless, odourless, and somewhat deliquescent, crystalline substance used as a camphor substitute in making "dope" and impregnating roofing-paper, etc.; m.p. 45° to 48° C., b.p. 410° C.; soluble in alcohol, acetone, amyl acetate, ether, and benzene.

"TRIPLEX"—A glass made to decrease splintering under impact. (See Glass (Laminated), p. 404.)

TRIPOLI (Tripolite)—Impalpable siliceous earth resulting from the natural decomposition of *chert* or siliceous limestone, used as an abrasive and polishing-powder. When pure it is white, and most of the grains are less than 0·01 mm. in diameter. (See Diatomite and Kieselgühr.)

TRISODIUM PHOSPHATE—See Sodium (Phosphates), p. 833.

TRI-STEARIN—See Stearin and Fats.

"TRITOLITE"—The trade name of a sodium soap used for separating the parts of emulsions of oil, water, and asphaltic substances, etc.

TRITURATION—Grinding to a very fine powder.

TRIVALENT—See Valencies.

TRONA—Natural deposits of sodium sesquicarbonate (crystal system, No. 5, and sp. gr. 2·1) mixed with potassium and boron salts, occurring in Egypt, Africa, the U.S.A., and South America. (See G. R. Robertson on the "Trona Enterprise" (*Ind. Eng. Chem.*, 1929, **21**, 520); Sodium (Sesquicarbonate) (p. 830), and Urao.)

TROPANE DERIVATIVES—See "The Chemistry and Chemotherapy of the Tropane Derivatives, including Tropine and Cocaine," by G. M. Dyson (*Ind. Chem.*, 1925, i, 328).

TROPINE—See Atropine.

TRUNCATION—The replacement of an edge or solid angle in a crystal by a plane or face.

TRYPONACIDES—See *Chem. and Ind.*, 1927, **46**, 627; J. G. Everett on "Trypanocidal Activity and Chemical Constitution" (*J.C.S.*, 1930, p. 2402); and A. Cohen (*J.C.S.*, 1932, p. 593).

TRYPSIN—An enzyme (digestive ferment) contained in the pancreas, capable of changing albuminous matters into so-called albumoses, in which partially hydrolysed and more soluble state they become converted into peptone. (See Enzymes, Peptones, and Zymogens.)

T'SAI YU (**CHING YU**)—The name of a vegetable oil obtained by primitive methods from the seeds of certain cabbage plants (*Brassica juncea* and *Brassica campestris*), used for common cooking purposes in China.

TSUBAKI OIL—See Tea-seed Oil.

TUNA OIL—See Fish Oils.

TUNGAY'S WATER-SPRAY NOZZLE—For use in sulphuric acid chambers, etc. (See *Chem. and Ind.*, 1929, **48**, 856.)

TUNG OIL (**Chinese Wood Oil, Hankow Wood Oil**) to the extent of from 40 to 53 per cent. is obtained by pressure of the sun-dried seeds of *Aleurites fordii* or *A. montana*, indigenous in China. It is also expressed in Madagascar, and known there as *Bakoby oil*. It is composed of glycerides, is generally pale yellow in colour, of drying character, cloudy appearance, unpleasant odour, and liable to solidify when kept. Supplies vary in physical characters, but on average the oil solidifies at −3° C., has a sp. gr. 0·936 to 0·943; sap. v. 190 to 195; i.v. 165 (Wijs); m.p. 47° C.; acid value about 7; and ref. ind. 1·5097 to 1·518 at 20° C. It comes to the market in various grades—colourless, red, black, yellow, etc. (the colourless or "white" variety being the best)—and is used as a waterproofing material for paper, and in making varnishes, driers, and linoleum. It contains a proportion of free fatty acids varying from 2 to 4·6 per cent., some olein, and from 71 to 74 per cent. of the glyceride of *a*-elæostearic acid ($C_{18}H_{30}O_2$), but for varnish-making it should be prepared so that the content of free acid does not exceed 1 per cent. (See J. Böeseken (*J.S.C.I.*, 1929, **48**, 71 T).)

A communication from Japan gives four Japanese varieties of trees

TUNG OIL (*Continued*)—

furnishing tung oil—viz., the *Aleurites cordata, A. fordii, A. montana,* and the Bakoby (*A. moluccana*), the seeds and endosperms of which yield as follows:

	A.	B.	C.	D.
Oil content in seeds, per cent.	37·77	44·11	37·43	23·61
Ditto in endosperm, ,, ,,	59·15	66·29	59·78	70·66
Specific gravity at 15° C. ..	0·934	0·9488	0·9372	0·9267
Saponification value ..	194·79	196·76	194·31	195·13
Iodine value (Wijs) ..	151·37	157·17	154·85	146·31
Refractive index (25° C.) ..	1·5065	1·521	1·5147	1·4785
Acid value	0·47	1·52	0·59	0·80
Reichert-Meissl value ..	0·39	1·10	0·35	0·71
Unsaponifiable matter, per cent.	0·41	0·59	0·99	0·97

Summarizing their analyses, Steger and Van Loon have given figures as follows:

Total fatty acids .. .. 91·3 per cent.

Saturated fatty acids—

Palmitic 3·7 per cent.
Stearic 1·2 per cent.

Unsaturated fatty acids—

Total fatty acids 91·3 per cent.
Saturated fatty acids 4·9 per cent. .. .. .. 86·4 ,, ,,

Volatile acids, aldehydes, etc., partially soluble in water 3·4 ,, ,,
Oxidized fatty acids .. .. trace
Unsaponified portion .. .. 0·6 ,, ,,
Glycerol as C_3H_2 .. .. 4·7 ,, ,,

(See reference below.)

In a more recent paper, J. Van Loon gives the following figures as representing the composition of Tung oil: Glycerin residue, 4·7 per cent.; unsaponifiable matter, 0·5 per cent.; volatile matter, 3·4 per cent.; saturated acids, 4·9 per cent.; Δ^9-oleic acid, 13·6 per cent.; and elæostearic acid, 72·8 per cent. (*B.C.A.*, 1930, B, 724.)

According to an investigation by Bolton and Williams, the amount of polymerizable matter and of the glyceride of elæostearic acid contained in tung oil are one and the same, varying from 71 to 74 per cent. (See *Analyst*, 1926, **51,** 335, and 1930, **55,** 360.)

It is frequently adulterated with cotton-seed, soya-bean, rape-seed, tea-seed, perilla, lumbang, and other oils. Experimental planting of tung-oil trees is being made in various parts of the British Empire, and with the view of obtaining an independent supply of pure oil, trees are

TUNG OIL (*Continued*)—

now being cultivated in the southern states of America and Hawaii with promising results. The fresh oil is stated to freeze at +3°, but after long periods it may remain fluid, although viscid, as low as −20°. In the absence of air, light changes it to a solid, consisting partly of unchanged oil soluble in acetone and insoluble crystalline β-elæostearin (m.p. 61° C.). It absorbs oxygen with avidity, polymerizes slowly when heated below 150° C. and out of contact with air, and this change proceeds more rapidly at 200° C., being quickly transformed to a jelly, and finally to a solid brittle state. There are certain difficulties in controlling the gelation stages of tung oil, but these are stated to disappear largely when it is mixed with linseed oil. Certain substances—for example, naphthenic acid, linseed oil, common resin, and glycerine—prevent the coagulation of tung oil, glycerine (6 per cent.) having the most effect.

In China and Japan the oil is used for varnishing wood and caulking boats, one Chinese varnish or brilliant oil known as "Kwangyui" being made from the oil by admixture with paraffin, while "Ningpo" lacquer is a mixture of the oil with lacquer used for furniture, etc.

References: Max. Toch (*J.S.C.I.*, 1925, **44,** 512 T, and following numbers up to No. 48, p. 527 T); E. Fonrobert and F. Pallauf (*B.C.A.*, 1927, B, 169); Steger and Van Loon (*J.S.C.I.*, 1928, **47,** 361 T, and *B.C.A.*, 1929, B, 103); J. Böeseken (*J.S.C.I.*, 1929, **48,** 71 T); L. A. Jordan (*Chem. and Ind.*, 1929, **48,** 847); J. Van Loon (*B.C.A.*, 1930, B, 724); a paper giving the characteristics of tung oil extracted from moisture-free kernels of *Aleurites fordii* and *A. montana* and the composition of the meals made from the whole nuts and the expressed nuts (*B.C.A.*, 1931, **50,** B, 30); report of discussion concerning this oil and its preparation for various purposes (*C.T.J.*, 1930, **86,** 479); paper on β-elæostearin from tung oil by Morrell and Marks (*J.S.C.I.*, 1931, **50,** 27 T); on the "Rhodanometry of Tung Oil," by J. Van Loon (*B.C.A.*, 1931, A, 602); and T. H. Barry (*Analyst*, 1932, **57,** 85).

TUNGSTEN (Wolfram) (W) **and its Compounds**—Atomic weight 184·1; sp. gr. variously given as 18·77 and 19·1; m.p. about 3,400° C. According to F. W. Aston (*Nature*, 1930, **126,** 913), this metal has four isotopes, and the atomic weight deduced is 183·96. It is a hard, grey, heavy, ductile metal of great tensile strength, highly prized for use in hardening and toughening steel specially made for high-speed metal-cutting tools, and (in a very pure state) for making the filaments of incandescent electric lamps filled with an inert gas such as argon or nitrogen. (See Smothells and Rooksby, *J.C.S.*, 1927, p. 1882.) For this latter application, the powdered metal is fused or sintered together in a hydrogen atmosphere by the passage of an electric current, the tensile strength of the finished wire of 0·0011 inch diameter being given as 270 tons per square inch.

The tungsten filaments were originally made by the Just and Hanaman process from the metallic powder held together by an organic binding material, and, after sintering, squirted so that the particles were held together by incipient fusion. It was later found that if tung-

TUNGSTEN (*Continued*)—

sten be worked—that is, compressed and hammered—when sufficiently hot (avoiding undue heating), it changes in some molecular manner so that it remains ductile when cold, and can be bent, rolled, or drawn hot or cold of sufficiently fine diameter through reduction dies.

Langmuir found that the blackening which occurs in these lamps as when first made was due to the deposition of a volatile tungsten oxide, and that this is avoidable by the scrupulous exclusion of water vapour. For this purpose a very high temperature is required in the filament, and this is realized by using it of much larger diameter or coiled in the form of a helix. These lamps are more than four times as efficient as the old carbon filament ones.

Nearly 20 per cent. is used in making the most efficient tungsten-chromium-vanadium high-speed steel, while for making permanent magnet steel 2 to 4 per cent. is employed. Nickel-tungsten alloys are used as the bases of acid-resisting materials; a lead-antimony-tungsten alloy is used in making firearms of small calibre and a copper-tungsten arc as a substitute for platinum for sealing into glass, while tungsten plating is superior to chromium plating and more resistant.

The metal can be obtained by the alumino-thermic reduction of tungstic oxide, or by its reduction with hydrogen gas in quartz or iron tubes at a temperature of 1,200° C. (See Thermite Process.)

According to J. A. M. van Liempt, the pure metal (99·3 per cent.) in powder form may be obtained in up to 80 per cent. theoretical yield by electrolyzing molten sodium tungstate at 950° with a current density of 15 amps/cm^2 in a quartz crucible, using tungsten electrodes (*B.C.A.*, 1925, B, 552). It can also be obtained of about 96 per cent. purity by reduction of the oxide (WO_3) with charcoal. There has recently been considerable development in the electrolytic preparation of the metal, using a slightly alkaline electrolyte of fused alkali tungstates, sodium being produced at the cathode and reacting with the tungstate. Metallic objects, particularly nickel and copper, or other metals coated with them, may be coated with tungsten by electrolysis in an acid electrolyte (*e.g.*, 38 per cent. Na_2WO_4, 32 per cent. Li_2WO_4, 30 per cent. WO_3) at over 900° C., the coatings being resistant to most acids but not to alkalies. (See *Chem. and Ind.*, 1929, **48**, 573.)

Finely divided tungsten powder causes the breaking up of alcohol at 350° C. into ethylene and water (Sabatier).

It occurs in nature as *wolfram* (*wolframite*, $(FeMn)WO_4$) and *scheelite*, the former term being often used to cover all minerals in which tungsten trioxide is combined with the protoxides of iron and manganese which vary widely in proportion; they are found chiefly in proximity to, or mixed with, tin ores. *Wolframite* is heavy, black, of crystal system, No. 5, and great specific gravity (7·1 to 7·9) so that it can be easily concentrated from the associated gangue, but not so easily from tin oxide (*cassiterite*); as, however, it is feebly magnetic, while the *cassiterite* is not, this property can be used to effect separation when associated. Deposits are found in France, England, Scotland, Cape Province, South Africa, Arizona, Germany, Portugal, Brazil,

TUNGSTEN (*Continued*)—

Australia, Bolivia, China (Kwangsi and Qwantung Provinces), Japan, Chile, Peru, and Argentine; China being the chief source of supplies. A small sample of ore from the Waichow district was found to contain 55·84 per cent. tungsten, 13·25 per cent. iron, and 11·56 per cent. manganese.

Scheelite, or calcium tungstate ($CaWO_4$), is a heavy yellowish or brown-purple mineral, wax-like in appearance, of crystal system, No. 2, and sp. gr. about 6·0; but the supply is small as compared with *wolframite.* It is chiefly used in the manufacture of ferro-tungsten, on account of the practical difficulties experienced in isolating the oxide for the preparation of pure metallic tungsten. Supplies come from the U.S.A., Bolivia, Portugal, Burma, Malaya, Australia, New Zealand, and Cornwall.

Above one-half of the natural supplies of tungsten ores is mined in the British Empire, a large proportion of the 302 tons of metal produced in 1918 having been obtained from tin mines, and 95 per cent. of the total ores was used in the production of high-speed tool and other alloy steels containing tungsten in proportions varying from 2 to 20 per cent. according to the application of the products.

The direct reduction of the ores—which yields ferro-tungsten suitable for most purposes—is effected by mixing the ore concentrates with anthracite and roasting in an open furnace, 1 ton of 98·5 per cent. metal being yielded by 2 tons of the purer concentrates. To prepare the metallic powder, the tungsten oxide (WO_3) has to be isolated from associated matters, and this can only be done by chemical processes involving the application of mineral acids or fusion with alkali, both methods being employed in practice. The acid attack is designed to dissolve out the iron, manganese, and other oxides, leaving the WO_3 as an insoluble residue; whereas, by furnacing with soda ash, tungstate of sodium is produced, and from this the yellow WO_3 can be precipitated by the addition of dilute acid. Other oxides are stated to exist—viz., W_2O_5 (deep blue) and WO_2 (chocolate colour). (See E. W. Engle, *B.C.A.*, 1927, B, 680). J. A. M. van Liempt disputes the existence of W_2O_5, and asserts the existence of a W_4O_{11} (*B.C.A.*, 1931, A, 583).

Tungstic oxide (WO_3) is said to yield a salt corresponding to potassium dichromate, but J. S. Dunn gives evidence of his view that this oxide is not a pure single substance, but consists of a mixture of α WO_3 and β WO_3 (*J.C.S.*, 1929, p. 1149). It can be prepared by digesting the ore or sodium tungstate with concentrated hydrochloric acid, dissolving the orange-coloured residue in ammonia, and precipitation of the oxide from the solution by use of hydrochloric acid. (See G. A. Percival (*B.C.A.*, 1925, B, 636), and Gero and Iredell (*B.C.A.*, 1928, B, 669).)

Both tungstic oxide and sodium tungstate are in demand for various minor industries.

Tungstic acid hydrate (H_2WO_4,H_2O) is a yellow powder, nearly insoluble in water, which can be obtained in a crystalline condition, and

TUNGSTEN (*Continued*)—

finds use as a mordant and for colouring porcelain. It is obtained by heating, in the first place, a mixture of ore and siliceous quartz in the vapour of carbon tetrachloride; the distillate of iron chloride is collected on dry potassium chloride; the carbon tetrachloride vapour is condensed, and that of the tungstic chloride is passed into dilute nitric acid, forming tungstic acid. It is obtainable in colloidal form by adding hydrochloric acid to a solution of sodium tungstate and subjecting to dialysis. Upon the basis of a recent research, A. M. Morley has arrived at the conclusion that there are four distinct types of tungstic acid. (See *J.C.S.*, 1930, p. 1987.)

Sodium tungstate ($Na_2WO_4,2H_2O$), a colourless crystalline body, made as already described, is soluble in water, and used for fireproofing fabrics and in the preparation of other tungsten compounds.

Tungsten carbide is used in making high-speed cutting tools, and calcium tungstate is used in connection with plates for translating X rays into rays of far greater wave-lengths of increased actinic power.

(See C. Coulson-Smith on "Tungsten Products" (*C.T.J.*, 1926, **79**, 248); H. T. S. Britton on "An Electrometric Study of Tungstic Acid" (*J.C.S.*, 1927, p. 147); "Recovery of Niobium Oxide from Tungsten Slags" (*C.T.J.*, 1927, **80**, 338); Britton and German on "Precipitation of Tungstates" (*J.C.S.*, 1931, p. 709); Fink and Jones on "Electro-Deposition of Tungsten" (*B.C.A.*, 1931, B, 930); R. H. Vallance on "Complex Acid Tungstates" (*J.C.S.*, 1931, p. 1421); and *The Metallurgy, Properties, and Applications of Tungsten*, by C. J. Smithells (Chapman and Hall, Ltd.).)

TUNGSTONE ACID PUMP—See Pumps.

TURACINE—A nitrogenous, organic, red colouring matter found in the feathers of the African birds named *turacos*, containing 8 per cent. of copper, doubtless derived from the local soil, which is known to contain malachite. Apart from the copper constituent, the colouring matter would appear to have much the same composition as the colouring matter of blood.

TURBIDIMETERS—Apparatus for measurement of low turbidities is described by J. R. Bayliss (*Analyst*, 1926, **51**, 270); see also Ingersol and Davis (*B.C.A.*, 1930, A, 1151); Zerban and Sattler (*Ind. Eng. Chem.*, vol. 3, July 15, 1931, p. 326); R. T. Balch (*Ibid.*, April 15, 1931, p. 124); *Ind. Chem.*, 1931, vii., 172; and Nephelometry.

"TURGOIDS"—Organized substances which swell in presence of water, but do not dissolve, such as raw hide, leather, textile fabrics, etc.

TURKEY RED—See Madder.

TURKEY RED OILS—Sulphonated castor oil made by heating 100 parts castor oil with 20 parts concentrated sulphuric acid at not exceeding 30° C., washing the product first with water and then with a solution of sodium sulphate: $C_{18}H_{33}O_2.OH + H_2SO_4 = H_2O + C_{18}H_{33}O_2.O.SO_3.H$.

Sodium hydroxide solution or ammonia is then added to the washed ricinoleo-sulphuric acid until it gives a clear solution with water, the resulting products being known commercially as "soda-olein" and

TURKEY RED OILS (*Continued*)—
"ammonia-olein" respectively. They are used in the dyeing, calico-printing, and leather industries, also for greasing wool to be spun.

Pure sodium ricinoleo sulphate has been separated from the sodium compound. It is readily soluble in water and has the composition expressed by $SO_4Na.C_{17}H_{32}CO_2Na,H_2O$. (See Nishizawa and Wino Kuti (*B.C.A.*, 1929, B, 363) and C. Sunder (*B.C.A.*, 1931, B, 355).)

In conjunction with alumina and colouring matters such as alizarin red (Adrianople red), these red oils form lakes and act as fixing agents.

One variety of "Turkey red oil" is prepared from Gallipoli or olive oil derived from the olives which have been allowed to become rancid and then oxidized by exposure to moisture and air.

Advantage is taken of the solvent and emulsifying properties of neutralized castor-oil sulphonation products in the preparation of a number of water-soluble defatting materials, such as "Tetrapol," "Tetraisol," "Lanapol," and "Verapol," used in the textile industries, these various preparations containing other substances in addition, such as hydrocarbons, chlorhydrocarbons, etc. (See Sulphonated Oil.)

TURMERIC (**Curcumin**)—A yellow or saffron colouring matter prepared from the roots of an East Indian plant (*Curcuma longa,* N.O. Zingiberaceæ), cultivated also in China, India, the East Indian Islands, and the Fijis; used for dyeing, also in pharmacy and medicine, as a constituent of curry powder and pickles, and for colouring butter, etc. (See Curcumenes.)

TURMERIC PAPER—Absorbent paper coloured with a solution of the yellow colouring matter of turmeric, which is turned brown by alkaline solutions, and is sometimes used in place of litmus paper. (See Volumetric Analyses.)

TURNBULL'S BLUE is generally represented as ferrous ferricyanide ($Fe_3(Fe(CN)_6)_2$), and is prepared by precipitating a solution of a ferrous salt with potassium ferricyanide (K_3FeCn_6). When prepared under certain conditions it is practically identical with Prussian blue. (See Prussian Blue.)

TURPENTINE—Oil or spirits of turpentine is a mixture of hydrocarbons (*terpenes*) produced by nature in pine trees, but spruce turpentine is said to consist largely of cymene and contains a small proportion of borneol. The crude exudation is collected by making cuts or slits in the bark of the trees, through which there exudes the oleo-resin known as *gum thus,* or "crude turpentine." This is done in winter, when the sap is dormant, a metallic apron being fixed below the cuts to divert the flowing material into receiving cups below. Upon distillation the spirit of turpentine passes over as vapour and is condensed, leaving resin behind.

The U.S.A. Government master specification in respect of gum spirits of turpentine and distilled wood turpentine requires for either type, $d\frac{15.5}{15.5}$, 0·860 to 0·875; $n\frac{20}{D}$ 1·465 to 1·478, etc. (See *B.C.A.*, 1927, B, 50.) Respecting the composition of commercial American turpentine, see Dupont and Barroud (*B.C.A.*, 1930, B, 248), and as to the

TURPENTINE (*Continued*)—

physical constants of wood turpentine from Russian *Pinus sylvestris*, see Krenstinski and Solodki (*B.C.A.*, 1930, B, 621).

There are many kinds of turpentine, meaning the crude products as they exude from the trees, and as many corresponding oils or spirits of turpentine.

American turpentine is obtained chiefly from *Pinus australis* and *Pinus tæda;* French turpentine from *Pinus maritima* and *Pinus pinaster;* Russian turpentine from *Pinus sylvestris* and *Pinus ledebourii;* German turpentine from the Scotch fir, *Pinus sylvestris* and *Abies pectinata*, etc.; Strasburg turpentine from the silver fir, *Abies pectinata;* Venice turpentine from the larch, *Larix Europæa;* Indian turpentine from *Pinus longifolia* Roxb.; Burma turpentine from *Pinus Khassyia* (corresponding to the American product); and Chian or Chio turpentine from *Pistacia terebinthus* and *Pinus vera.* Indian turpentine, from *Pinus longifolia*, contains a mixture of terpenes, including the diterpene named carene ($C_{20}H_{32}$), and resembles Russian turpentine in susceptibility to oxidation by air, etc. (See Owen and Simonsen, *J.C.S.*, 1931, p. 3001.)

Enormous quantities of turpentine, reported to be equal in value with the best French and American productions, are said to be available in the Gajolands of Sumatra.

"Pine-cone oil" is obtained by distilling the cones of *Abies pectinata* with water, and "pine-leaf oil" similarly from the leaves of *Pinus sylvestris* or *Pinus abies.* There are also varieties of so-called "pine-needle oils" prepared from the needles of the various species of pines.

That part of the crude turpentine which concretes upon the bark of the trees tapped for turpentine in France is variously called *galipot* and *barras*, and is for the most part ordinary resin (colophony).

The turpentines find certain uses in their crude forms as exuded from the trees which produce them, but for the most part the spirit or oil is first of all distilled from the crude materials, and is then utilized as solvent, volatile vehicle, or otherwise in connection with many manufactured articles, including synthetic camphor, paints, polishes, leather dressings, varnishes, disinfectants, etc., also in pharmacy and medicine.

It has been demonstrated that the deleterious effects sometimes attributed to white-lead paints have no connection whatever with the turpentine used in compounding them. (See White-Lead, pp. 525 and 987.)

Turpentine spirits, irrespective of source, are colourless mobile fluids each of more or less characteristic odour, insoluble in water, but soluble in alcohol, ether, and carbon disulphide, and miscible with many other organic fluids. They vary in specific gravity from 0·865 to 0·875, boiling-points from 160° to 162° C., and optical rotatory power, and they differ not only in respect of their several origins, but to some extent even among themselves from a common source.

American turpentine exhibits a refractive index of 1·4719 at 20·5° C. (sodium flame), and the mean temperature coefficient has been given

TURPENTINE (*Continued*)—
as 0·000468. Its density at 15·5° C. is about 0·869, and iodine value about 400.

American "stump turpentine" is that obtained from the wood and stumps of the trees, and differs in various respects from the spirit turpentine obtained from the oleo-resin. (See M. J. Roimersma (*C.T.J.*, 1927, **81**, 467), and I. W. Humphrey (*Ind. Chem.*, 1931, vii., 119).) The so-called sulphite (spruce) turpentine contains a good proportion of *p*-cymene, and mixtures with organic solvents such as acetone, isopropyl, and other alcohols, constitute good paint and varnish removers.

Russian turpentine as found on the market is of various kinds, the genuine spirit being obtained from the oleo-resin after the manner observed in producing the American spirit, but for the most part in the past it consisted of the distillate obtained from the tree-stumps and other parts of the trees by direct fire, and hence, when so produced, contains some proportion of the destructive products of the wood, tar, and the oleo-resin mixed with the turpentine, and these necessarily vary both in nature and proportions with the varying temperatures which obtain in this crude process. There is also a Russian stump turpentine obtained by steam distillation of the wood.

Turpentine, in common with all terpenes, as Kingzett has shown, rapidly oxidizes when exposed to the air, oxygen, or ozone, and produces a body of the character of an organic peroxide, which dissolves in the oil, and in presence of water gives rise to the formation of hydrogen dioxide, associated with several organic bodies, and advantage is taken of this property in the manufacture of "Sanitas" disinfectants. This absorptive capacity for oxygen is more pronounced in the Indian and Russian classes of turpentine. (See R. C. Palmer, *C.T.J.*, 1930, **87**, 176; also Balsams, Camphor, Essential Oils, Pine Oil, Resins, and Terpenes (pp. 456 and 904).) For a contribution to the chemical composition of Russian turpentine from *Pinus sylvestris* see B. Arbouson (*B.C.A.*, 1929, B, 529) and Sylvestrene.

TURPETH—See Mercury.

TURQUOISE—A gem consisting of hydrated aluminium phosphate ($Al_2O_3,P_2O_5,5H_2O$), of sp. gr. 2·6 to 2·8, coloured by copper and iron oxides, found in certain Persian provinces, Mexico, etc.

TUSCAN RED contains from 40 to 60 per cent. ferric oxide (Fe_2O_3), brightened with some organic red dyestuff.

TWADDLE'S HYDROMETER—See Hydrometers.

TWITCHELL—See Fats (pp. 335-336) and Soaps (p. 820).

TYPE-CLEANING AGENTS include preparations known as "Hexalin," "Cornedol," "Duferol," "Pinol," "Cykloran," "Nutrilan," etc. (See A. Noll, *C.T.J.*, 1929, **85**, 598.)

TYPE METAL—Alloys of lead, antimony, and tin, with occasionally copper and bismuth. (See Alloys.)

TYRIAN PURPLE—A purple dye chemically associated with indigo, extracted from the cyst or vein near the head of a mollusc (sea-snail) found in the Mediterranean (genus *Purpura* or *Murex*). Dibromo-indigo forms a large proportion of the colouring-matter of the shell-fish purple, and can be made synthetically.

TYROSINE ($C_9H_{11}NO_3$ or $OH.C_6H_4.CH_2.CH(NH_2)CO_2H$)—A crystalline body of silk-like lustre, sparingly soluble in cold water, alcohol, and ether, but soluble in boiling water. It is of amino-acid character and found present in the pancreatic gland, in old cheese, and as a product of putrefactive decomposition of some albuminous substances and bodies resulting from their chemical hydrolysis. It forms a definite, additive, crystalline hydrochloride ($C_9H_{11}NO_3,HCl$) with hydrochloric acid, and is one of the organic substances that have been built up synthetically.

UCUHUBA OIL—The ucuhuba fruit, which grows in Brazil, is utilized for the production of oil used for incorporation in Italian margarine.

"UDYLITE" Process of Cadmium Plating—See Electricity, p. 293.

ULEXITE—See Boron.

ULLMANITE—A mineral compound of sulphur, antimony, and nickel, sometimes represented as SbNiS, occurring in crystal system, No. 1, and sp. gr. 6·0 to 6·5.

ULMINS—Coal constituents. (See W. Francis and R. V. Wheeler (*J.C.S.*, 1925, cxxvii., 2236); also Coal, pp. 202 and 204.)

ULTRA-CENTRIFUGE—See Centrifuges and Particles.

ULTRA-FILTRATION—See Filters.

ULTRAHUMIN—See Coal, p. 202.

ULTRAMARINE—A valuable blue pigment of complicated composition containing aluminium in the form of silicate found in Persia and Turkestan and known as *lapis lazuli*. The ultramarine of commerce is made artificially by exposing to a red heat in tightly closed crucibles or muffle furnaces, but below fusing-point (750° to 800° C.), a mixture of kaolin or powdered quartz of high purity, sodium carbonate or caustic soda, sulphur, and charcoal (or pitch, tar, or resin), supplemented by some subsequent treatment. Its exact constitution is not known, but it may be regarded as a double silicate of aluminium and sodium in association with sodium sulphide. There are other modified processes of manufacture, and it can be made of various tints —green, red, and violet included. (See C. H. Butcher, *C.T.J.*, 1930, **87**, 634.) Iron is the most dangerous impurity, of which not more than 0·5 per cent. must be present on account of its darkening effect, and it is very easily decomposed by the slightest trace of acid. Its essential formula has been given as $Na_4(NaS_3.Al)Al_2(SiO_4)_3$. Another description gives the "poor in silica and rich in sulphur" blue type as represented by the formula $Na_8Al_6Si_6S_4O_{24}$, and the "rich in silica

ULTRAMARINE (*Continued*)—

and poor in sulphur" type as $Na_6Al_4Si_6S_4O_{20}$. One mixture used for producing a bright blue product consists of 540 kilos kaolin, 8 kilos caustic soda, 538 kilos soda ash, 268 kilos sulphur, and 46 kilos charcoal. Another satisfactory mixture is given as follows:

	Per Cent.
Kaolin	30·5
Silica	6·5
Caustic soda	0·5
Sodium carbonate	27·0
Sulphur	31·5
Carbon	4·0

The product after cooling is finely ground under water and subsequently dried and sifted. It is used in making laundry blues, mottled soap, paints, colours, and in paper manufacture.

Various types of ultramarines, inorganic, organic, and inorganic-organic are described by J. Hoffmann (*B.C.A.*, 1929, A, 1251); see also J. S. Remington on "The Constitution and Manufacture of Ultramarine Blue" (*Ind. Chem.*, 1926, ii., 79); J. Watson (*Ibid.*, p. 201); Jaeger and van Melle (*B.C.A.*, 1927, B, 915); F. M. Jaeger (*B.C.A.*, 1929, B, 494); Jaeger and Melle (*Ibid.*); and F. M. Jaeger (*B.C.A.*, 1932, A, 140).

The present world production has been estimated at about 20,000 tons per annum. (See *C.T.J.*, 1927, **81,** 529 and 541.)

ULTRA-MICROSCOPE—See Micron and Microscopes.

ULTRA-VIOLET RAYS—Light (health) rays forming the shorter ones (wave length 0·1 to 0·4 microns) of the spectrum lying behind the violet rays, to which the human eye is not sensitive. They have some bactericidal power, are capable of effecting or intensifying many chemical changes, including bleaching effects on textiles, etc., and causing fluorescence of quinine solutions, honey, etc. They have been successfully applied (by taking advantage of their fluorescent effects) for discriminating between Japanese pearls and other kinds, and vegetable and mineral oils; for determining the purity of many chemicals (see *Chem. and Ind.*, 1927, **46,** 467); for distinguishing between cotton, wool, and silk, various kinds of card and paper, and old masters and faked pictures, as each pigment has its own fluorescence. (See P. Heerman on "Action of Ultra-Violet Rays on Dyed Textiles" (*J.S.C.I.*, 1925, **44,** 68); and article on "Tests for Old Masters" (*The Times*, February 11, 1929, p. 17).)

A method used for determining the amount of ultra-violet radiation in the atmosphere employs a quartz tube containing a standard solution of acetone and methylene blue exposed at the top of a mast, the amount of bleaching which ensues in the solution by comparison with standardized tubes giving a biological indication. Each degree of the standardized scale is equivalent in value, and represents twice as much radiation as suffices to produce a slight erythema or flushing of the average sort of skin. A measurement of, say, 5 degrees means that the power of the

ULTRA-VIOLET RAYS (*Continued*)—

rays from skyshine and direct sun together, fades the standard acetone solution exposed in the standard quartz tube 5 points on the scale. Thus in a central part of London on a misty day in December the amount may be nil (owing to loss attributed to smoke pollution), while it may be 23 in open country in July and on an August day in Switzerland as high as 41 degrees. (See Moss and Knapp, *Analyst,* 1929, **54,** 334.)

Ultra-violet rays pass through ordinary commercial tracing cloth (or linen) to a large extent (*Nature,* 1929, **123,** 47), and after exposure to them a number of salts affect a photographic plate (E. Montignie, *B.C.A.*, 1929, A, 1152).

Under the influence of ultra-violet light, carbon dioxide is converted into formaldehyde and finally into a kind of sugar, and these changes have been shown to occur in concert with the action of chlorophyll in living plants. (See two papers by Gillam and Morton (*J.S.C.I.,* 1927, **46,** 415 and 417 T).)

These rays are credited with healing qualities in respect of cancer, etc., also with the power of conferring anti-rachitic properties and increasing this qualification in respect of many substances, including dried milk, flour, certain vegetables, certain oils, sterols, etc., and of exercising a stimulant action on animal life.

The light obtained from quartz mercury-vapour, carbon arc, and tungsten arc lamps respectively, is rich in ultra-violet radiations, and has found application in the treatment of rickets, as a test for colour fastness, for sterilizing water, and for distinguishing synthetic from other tannins. The opinion has also been expressed (by J. C. Drummond) that ultra-violet light acting on the skin of human beings induces the direct increase of vitaminous constituents.

(See report of lecture by A. A. King (*Chem. and Ind.,* 1927, **46,** 555); Moss and Knapp on "The Standardization of Ultra-Violet Light" (*J.S.C.I.,* 1925, **44,** 453 T); W. T. Field on its use for detection of solvent-extracted cocoa-butter; E. R. Bolton on "Oils under Ultra-violet Light"; and C. A. Mitchell on "Inks and Ultra-violet Light" (*Analyst,* 1930, **55,** 744); the "chemical action" of these rays, subject of a book by Ellis and Wells (Chemical Catalog. Co., Inc., New York), and *The Spectroscopy of the Extreme Ultra-Violet,* by T. Lyman (Longmans, Green and Co., Ltd., London); also Mercury Micro-lamp, Photo-catalysis, Radio-activity, Vitamins, Wave-lengths, and X Rays.)

UMBELLULARIA OIL, from the nut of the Californian laurel (*Umbellularia Californica* Nutt). (See Weinhaus and another, *B.C.A.,* 1929, B, 1049, and compare Laurel Oil.)

UMBERS (**Sienna**)—Pigments used in paint-making, staining, and the paper trade, consisting of natural oxide of iron allied to ochre; one variety is in the nature of a brown silicated hæmatite of the composition $2Fe_2O_3,SiO_2,H_2O$. The deposits vary in colour (from yellow to brown) and in composition, the colouring being attributed to proportions of manganese compounds and alumina. Varieties occur in Italy,

UMBERS (*Continued*)—

England, and other places, and are prepared for the market by grinding, washing, and then drying at 100° C. Burnt umber is the calcined product, and is darker in colour. (See Ochre and Vandyke Brown.)

UNI—Prefix meaning same as mono.

UNITS—See Electricity (pp. 297 and 298), Force (p. 369), and Heat (p. 434).

UNIVALENT—See Valencies.

UNSATURATED COMPOUNDS—See Valencies.

UPAS (Malay Poison)—Arrow poison used in the East Indies, obtained from the milky juice of the *Upas antjar, Upas radja,* and some kinds of *Strychnos,* the best known being said to be prepared from the gum which exudes from incisions in the stem of the anchar tree (*Antiaris toxicaria*).

URALITE (Amphibole)—Horn-blende from Ural districts. (See Amphibole, Asbestos, and Horn-blende.)

"URALITE"—This name is also given to a hard, rigid make of asbestos millboard, composed of high-grade asbestos fibre with silicate as a binding agent and described as absolutely fireproof; used for making partitions, linings, fire-proof curtains, etc.

"URANINE" ($Na_2C_{20}H_{10}O_5$)—A yellow, crystalline dye, obtained by treating fluorescein with sodium carbonate; used also for following the course of subterranean waters, etc.

URANINITE—See Foshag and Short (*B.C.A.*, 1931, A, 817); Pitch-blende and Uranium.

URANITE—Uranium minerals, one of which is a phosphate of uranium and copper, and the other a phosphate of uranium and calcium.

URANIUM (U) **and its Compounds**—Atomic weight 238·1; sp. gr. 18·7. This metal is contained to the extent of from 40 to 90 per cent. as oxide in association with other compounds in the mineral *pitch-blende* (uraninite (UO,U_2O_3)), which is found in some Cornish mines, Austria, Colorado, and elsewhere. It also occurs in *bröggerite, cleveite,* and *uranite,* and a number of other minerals, including *carnotite, fergusonite, samarskite,* etc.

Brannerite is the name of a uranium mineral found in the pegmatites obtained from gold placers in Idaho. It is described as a complex titanate of uranium, associated with smaller quantities of rare earths, including as much as 50 per cent. of uranium oxides.

"*Soddite*" is the name given to a radio-active silicated uranium mineral found in association with "*curite*" in the Belgian Congo, and contains about 85·33 per cent. UO_3.

The best deposits of uranium ores so far known, apart from the Cornish pitch-blende, are those severally found at Joachimsthal in Bohemia, Johanngeorgstadt in Saxony, Colorado, and Utah, the content rarely exceeding 2 or 3 per cent.

URANIUM (*Continued*)—

It is the heaviest known element, ductile, silver-white in appearance, melts at between 1,500° and 1,800° C., is soluble in acids, and made by reduction of the oxides with carbon in the electric furnace. It can also be prepared by reduction of the dioxide with metallic calcium at from 950° to 1,250° C. in an iron crucible lined with lime; or by reduction of the green crystalline tetrachloride (which results from heating the oxide U_3O_8 to 500° C. in a current of sulphur chloride vapour, and subliming the product in a current of chlorine) with metallic sodium or calcium.

As prepared by the action of metallic sodium upon the tetrachloride by fusion, operating in argon at 50 to 100 atmospheres, it has the appearance of polished iron, but readily tarnishes in the air.

E. Botolfsen has described a method for preparing it in pure form by heating the oxide U_3O_8 and metallic calcium *in vacuo* in an iron tube at a temperature above the m.p. of calcium (*B.C.A.*, 1929, A, 1253).

Heated to 170° C. it burns brilliantly in the air, and in boiling water the metal gives rise to the formation of the hydrated oxide.

There are an indefinite number of oxides (which are insoluble in water), the best known being represented by the formulæ UO_2, UO_3, and U_3O_8, all of which are used in the ceramic industries, and amongst the other better-known salts are uranous sulphate ($U(SO_4)_2$), chlorides (UCl_3, UCl_4, and UCl_5), and the uranyl nitrate ($UO_2(NO_3)_2$) (used in photography). The uranous salts, of which the best known are the nitrate and acetate, are green and the uranic ones yellow in colour; most of them are soluble in water, and are remarkable for their extreme fluorescence.

Some uranium compounds (including sodium uranate, Na_2UO_4, a yellow salt soluble in dilute acids) are employed to give a yellow fluorescent. colouration to glass, whilst the lower oxide gives a fine black colour, and the acetate is used in dyeing and calico-printing.

As an element, uranium is the more interesting, as by some sort of molecular disintegration it is surmised to give rise to the production of not only radium and helium, but also some peculiar radium emanations (distinct in some respects from radium), and a peculiar form of lead. The radio-active constituent of uranium salts is, as reported, precipitated from solution by ammonia, but in course of time the radio-activity is recovered. (See Lead, Radio-activity, and Radium.)

URANYL—The divalent radical UO_2 of uranyl nitrate and uranic acid ($UO_2(OH)_2$).

URAO—See Sodium (Sesquicarbonate) (p. 830) and Trona.

UREA (**Carbamide**) (CH_4N_2O) or ($CO(NH_2)_2$)—A white, crystalline, substance known as a constituent of urine, resulting from oxidation of certain nitrogenous bodies in the animal organism, of which an adult man excretes about 30 grms. daily. It is soluble in water and alcohol, melts at 132° C., sublimes when heated *in vacuo*, and forms compounds

UREA (*Continued*)—

with acids and with bases. Ammonium cyanate is easily transformed into urea (with which it is isomeric), and urea can also be made by the action of ammonia on ethyl carbonate or by the action of mercuric oxide on oxamide. The value of urea as a fertilizer, containing as it does 46 per cent. nitrogen, has long been recognized, and more recently established by the results obtained with calcium cyanamide, from which urea results as the first product of hydrolysis. Its use in making synthetic resins and other of its applications is the subject of an article by T. H. Fairbrother (*Ind. Chem.,* 1927, iii., 34), and it is useful for removing the lustre of cellulose acetate silk. There is a process for the manufacture of urea from synthetic ammonia and carbon dioxide, depending upon the conversion of solid ammonium carbamate by heat, in an autoclave at about 150° C., thus ($NH_2.CO.ONH_4 = CO(NH_2)_2 + H_2O$). The carbamate is prepared from its constituents in a gaseous state, and about 40 per cent. is thus transformed and left in a pure state in the still, any carbamate and its gaseous dissociation products which pass over being subsequently recovered. By the use of thoria as a catalyst the yield of carbamate from ammonia and carbon dioxide is much increased, some 50 per cent. of the latter being converted, provided that the ammonia is always present in excess.

Carbamide, together with ammonium cyanate, is formed when a mixture of carbon dioxide and ammonia is passed at atmospheric pressure through the annular space between a water-cooled glass tube and an outer quartz tube heated to 500° in an electric furnace. The yield increases with the use of thorium oxide as a catalyst, and by increasing the temperature up to 700° C. (See *J.C.S. Abs.*, February, 1925, I., 121; J. Jakovkin (*B.C.A.*, 1929, B, 971); Krase (with others) (*B.C.A.*, 1930, B, 408); and Ammonium Carbamate, p. 616.)

Another process reported to give a practically quantitative yield of urea consists of the treatment of cyanamide in strong aqueous solution with an acid catalyst—sulphuric, phosphoric, or nitric acid—at below 75° C. and under some pressure (using less than 10 per cent. of the amount of acid required to form a salt with the urea), after which the mixture is neutralized with calcium carbonate, filtered, and evaporated. A continuous process for its manufacture from liquid ammonia and liquid carbon dioxide as developed by Krase, Gaddy, and Clark is described in *Ind. and Eng. Chem.*, March, 1930.

The manufacture of urea and its use as a fertilizer is the subject of a Canadian bulletin (*C.T.J.*, 1927, **81,** 101), and its production by the Lidholm process from calcium cyanamide is described by J. H. Lidholm (*C.T.J.*, 1925, **77,** 515). A patented use for urea is its employment for "carroting" hair as used for making felt.

One ton of nitrogen is contained in every 2·14 tons of urea, as compared with the same content in 4·71 tons of ammonium sulphate and 6·07 tons of sodium nitrate; and it has been found superior to ammonium salts and sodium nitrate as a fertilizer for rubber trees, at the same time acting as a protective against defoliation or so-called "secondary leaf-fall." (See Cyanic Acid (p. 260), Fertilizers, and Guanidine.)

UREASE—See Enzymes, p. 312.

UREIDES—Bodies analogous to the amides, being derivatives of urea with acid radicals such as acetyl-urea ($H_2N—C:O.NH.CO.CH_3$) and oxalyl-urea (parabanic acid) $CO(NH)_2 2CO$.

UREOMETER—An apparatus for quantitatively determining the amount of urea contained in urine, by measuring the nitrogen gas evolved in its decomposition by sodium hypobromite in sodium hydroxide solution.

URIC ACID ($C_5H_4N_4O_3$) or ($CO(NH)_2.CO.C_2.CO(NH)_2$)—A white crystalline constituent of urine, forming the principal part of urinary calculi and deposits; very slightly soluble in water.

It is also found in the urine of birds and serpents, and gives rise to a number of derivates—including alloxan ($C_4H_2N_2O_4$)—which may be viewed as amides containing the radical C_2O_2 of oxalic acid.

URINE—An excretory liquid containing part of the soluble broken-up or waste products of the living organism. It has an average sp. gr. of 1·02, and amounts to from 1,400 to 1,600 c.c. per twenty-four hours, containing dissolved solid matters to the extent of from 50 to 60 grms., including urea, uric acid, kryptophanic acid, kreatine ($C_4H_9N_3O_2,H_2O$), kreatinine ($C_4H_7N_3O$), other alkaloidal bases, smaller amounts of undetermined and varying constituents, various colouring matters, and mineral salts, including sodium chloride, phosphates, sulphates, etc.

Kryptophanic Acid ($C_{10}H_{18}N_2O_{10}$) is the normal free acid of human urine, and it has been stated that hippuric acid, which is a normal constituent of the urine of herbivorous animals, is sometimes, if not always, present in small quantity in the human liquid excretion. (See Thudichum's *Annals of Chemical Medicine,* vol. i., chapter xii. (Longmans and Co.); D. L. Dvarkin on "Urochrome as the Colouring Matter of Urine" (*B.C.A.*, 1930, A, 1467); Albuminometer and Ureometer.)

UROTROPINE—See Hexamine.

"USCO"—An iron alloy. (See Iron (Cast or Pig).)

"U" TUBES—See Drying Tubes.

VACCINES—Modified viruses, including dead and living varieties, but generally sterilized by heating or by antiseptics before use. (See *Immunity in Infectious Diseases,* by A. Besredka (Baillière, Tindall and Cox); Bacteria, Chemotherapy, Toxins, and Viruses.)

VACUUM—A space devoided of air or gas as far as practicable, as, for example, the exhausted glass lamps used for electric lighting. The highest attainable vacuum is, in fact, only an intensely attenuated atmosphere still containing some millions of molecules. If the degree of exhaustion be carried far enough, an electrical discharge from a source of high potential electricity will not pass from pole to pole; similarly, the ticking of a watch placed in such a space becomes inaudible.

VACUUM (*Continued*)—

According to R. C. Burt (*J. Opt. Soc. Amer.*, 1925, **11**, 87-91), pure sodium can be introduced into the high vacuum of an electric light bulb by immersing it in a bath of molten sodium nitrate, which is thus electrolyzed by using the thermionic emission from a filament.

An absolute vacuum cannot be realized, as apart from the original constituent gas occupying the space (a proportion of which, however infinitesimally small, must be left), there may be penetration, due to stress, through the vessel from external matter or from that constituting the materials (apparatus) employed. (See M. Crespi (*B.C.A.*, 1927, A, 406).)

The (Dewar) thermos flask has a largely vacuous annular space between the two glass vessels of which it is constructed, and commercial metallic vacuum vessels constructed on this principle are made for the storage of low-boiling liquefied gases and other liquids for general use.

See notes by H. Calam on the installation and maintenance of a vacuum service (*Ind. Chem.*, 1929, v., 469); Kuss and Ritter on "Vacuum Apparatus in Industrial Laboratories" (*B.C.A.*, 1930, A, 1394); a new vacuum oven for drying at high temperatures (*Ind. Chem.*, 1927, iii., 232); a vacuum crystallizer (*Ibid.*, 558); article by G. W. Riley on "Vacuum Drying" (*C.T.J.*, 1928, **83**, 545); *Vacuum Practice*, by L. Dunoyer (G. Bell and Sons, Ltd.); and *High Vacua*, by G. W. C. Kaye (Longmans, Green and Co.); Attenuation, Pumps, and Radio-activity.

"VACUUM SALT"—See Sodium Chloride, p. 825.

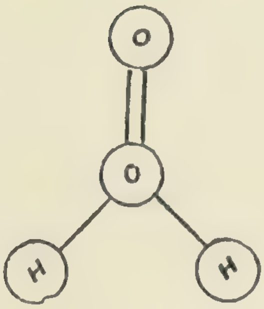
VALENCIES—The atoms of elements (as chemically understood) possess powers of combination, or so-called *valency*, indicative of the number of other atoms with which an atom of an element can directly combine. Hydrogen is a so-called *uni*valent or *mono*valent element—that is, it has only one capability of chemical attachment to another element. Thus, it may be made to combine with chlorine, graphically represented as follows:

Hydrogen, then, and the other elements which have a similarly restricted valency are called monads.

Oxygen, on the other hand, generally behaves as a *bi*valent (*di*valent) element or dyad, and can combine, for example, with 2 atoms of hydrogen or other monovalent element, as shown by the constitutional formula of water, H_2O, graphically expressed thus:

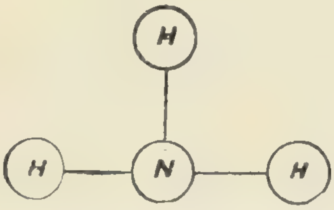
In other combinations, oxygen behaves as a tetrad—as, for example, in hydrogen dioxide (H_2O_2):

VALENCIES *(Continued)*—

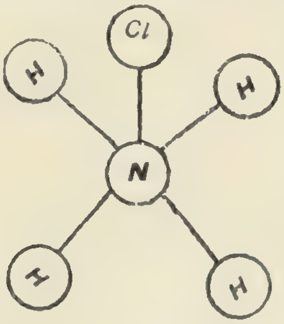


This represents the view that 1 atom of oxygen is attached, on the one hand, directly to the 2 atoms of hydrogen, and (as there is good reason for thinking) the other atom of oxygen is not in direct attachment with the hydrogen atoms.

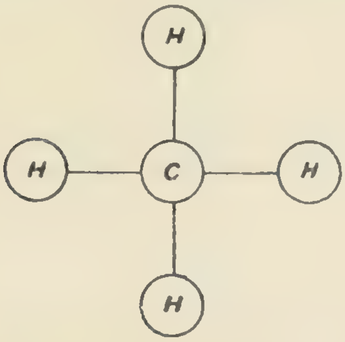
Nitrogen is an example of a *tri*valent element (triad), although in some compounds it behaves as a pentad. For example, in ammonia (NH_3) it exists in combination with 3 atoms of hydrogen, and may be represented as follows:



whereas, combined as in chloride of ammonium (NH_4Cl), it would appear to exist in pentavalent combination, thus:



Carbon is an example of the quadrivalent (tetrad) class; that is to say, it has the power of combining with 4 atoms of hydrogen or 2 atoms of oxygen, as expressed in the two following graphic formulæ:



Methane or marsh gas.

Carbon dioxide.

VALENCIES (*Continued*)—

Hexads are elements with a valency of 6 as exhibited by some compounds of chromium and sulphur.

The doctrine that the "form" of the carbon atom is that of a regular tetrahedron was originated by Van't Hoff. (See H. E. Armstrong and W. Barlow on "The Modes in which Valency is Exercised" (*Chem. and Ind.*, 1928, **47,** 892 and 897).)

According to the Lewis-Langmuir "octet" theory, the elements owe their valency to a force that urges them to build up groups of 2, 8, 18, or 32 electrons, effected by transferring electrons from one atom to another, or by sharing electrons between adjacent atoms. Under this view it will be seen that chemical affinity is given a materialistic character and is based upon an interchange of the electrons of the respective substances concerned, with or without polarity. (See Atoms, Chains, Chemical Interactions, and Co-ordination.)

Saturated Compounds are those in which there are no unsatisfied affinities—for example, the normal hydrocarbons (paraffins) of which methane (CH_4) is typical, the tetravalency of carbon being fully satisfied by combination with 4 atoms of hydrogen. Again, phosphoric pentoxide (P_2O_5) is a saturated body, the 2 atoms of phosphorus (which is pentavalent) being satisfied by combination with 5 atoms of divalent oxygen.

Unsaturated Compounds possess unsatisfied affinities, such as phosphine (PH_3), in which three only out of the five affinities are saturated by combination with hydrogen, leaving two unsatisfied. Unsaturated compounds can take up hydrogen, halogens, etc., to produce saturation; thus CO can, by combination with Cl_2, become $COCl_2$; again, ethylene (C_2H_4) may be regarded as only a half-saturated compound, becoming saturated when converted into ethane (C_2H_6), as double linkages do not cause unsaturation.

See "Valency Terminology," by J. D. Main Smith (*Chem. and Ind.*, 1927, **46,** 188); *The Parachor and Valency,* by S. Sugden (Routledge and Sons, London); *The Electronic Theory of Valency,* by N. V. Sidgwick (Oxford University Press); and Octet Theory.

VALERIAN—The dried rhizome and roots of *Valeriana officinalis* (var. *angustifolia,* N.O. Valeriana) which is widely distributed throughout Europe and Northern Asia, and cultivated in England, Holland, Germany, and the U.S.A. It contains starch, a resinous substance, the essential oil of valerian, small quantities of two alkaloids, and other substances; 100 parts of the root yielding from about ½ to 1¼ parts of the oil, which can be obtained by distillation with water. The oil is used in perfumery, has a sp. gr. of 0·94 to 0·965, and is soluble in alcohol and ether. It is of complicated composition, containing some proportion of a sesqui-terpene, borneol, also some valeric and formic acids; is yellow-greenish in colour, soluble in alcohol and ether, and has a characteristic strong odour and aromatic taste. An old sample of the root is reported to have yielded a petroleum spirit extract of 1·64 per cent. containing 47·4 per cent. of oleo-resin or material soluble in 70 per

VALERIAN (*Continued*)—

cent. alcohol. The medicinal (carminative) action of the root is really that of the oil. (See K. Bullock, *Pharm. J.*, 1926, **117**, 173.)

The Japanese valerian oil known as *kesso oil* is a green, thick liquid of sp. gr. 0·996 and some medicinal value.

VALERIC (VALERIANIC) ACID ($C_5H_{10}O_2$ or $(CH_3)_2CH.CH_2.CO_2H$)—A colourless, oily acid of the fatty series which bears a similar relation to amyl alcohol as acetic acid to ethyl alcohol. It is of unpleasant odour and is said to exist in four different modifications, the normal variety being a liquid which boils at 185° C., and is soluble in alcohol and ether. One of the varieties is found naturally in many plants, particularly valerian root (see Valerian) and in angelica root from which it is obtained by boiling with soda.

Valeric acid is a frequent product of the oxidation of the higher fatty acids, and can be prepared by the oxidation of amyl alcohol. It is used in medicine and perfumery.

VALONIA—Acorn cups and beards of the *Quercus ægilops, Q. robur,* and *Q. suber,* rich in tannin; grown in Asia Minor, Turkey, France, Greece, and Roumelia, and used for tanning. Good qualities contain about 30 per cent., while Messenia valonia is stated to contain the highest percentage of tannin. An extract containing 64 per cent. tannin is prepared in Smyrna, and other extracts are commercially available.

VANADINITE—Mineral chloro-vanadate of lead, of crystal system, No. 3, and sp. gr. 6·6 to 7·0. (See Vanadium.)

VANADIUM (V) **and its Compounds**—Atomic weight 50·95 and alleged isotope 51; sp. gr. of crystalline form 5·8, and of powder 5·5; m.p. about 1,720° C. The atomic weight has recently been determined as 50·947 (Scott and Johnson, *J. Amer. Chem. Soc.*, 1930, **52**, 2638). It is a somewhat rare metallic element which occurs naturally in some minerals, including *endlichlite* or *vanadinite* (lead combination) ($9PbO,3V_2O_5.PbCl_2$), *pucherite* (a bismuth combination), *mottramite* (a lead and copper combination), *patronite* (an impure vanadium sulphide mined at Mina Ragra in Peru), *roscoelite* (a silicate), *sincosite* (a new vanadium mineral found in Peru) (V_2O_4,CaO,P_2O_5,H_2O), and *carnotite* (a uranyl-potassium vanadate). It is also found present in Bessemer slag at times, being derived from certain iron ores in which it occurs naturally in small amount.

The chief source of the metal lies in the Peruvian Andes and S.W. Africa, and recently certain deposits of siliceous clay have been located near Budleigh Salterton in Devonshire containing up to nearly 14 per cent. V_2O_5 in the best darker portions (see G. E. L. Carter, *B.C.A.*, 1931, A, 1390).

Vanadium is recovered as oxide from the sulphide present in the mixture of *patronite* and asphaltic material found at Mina Ragra in Peru, by roasting the ore with a little added coal; the vanadium passes into the slag, which is granulated in water, dried, and reduced to ferro-vanadium in a shaft furnace. Another method consists in roasting the ore with salt, thus producing sodium vanadate, which can be separated

VANADIUM (*Continued*)—

by solution in water, and then treated with hydrogen sulphide, the precipitated sulphide thus produced being subsequently reduced to oxide or to the metallic state, the latter being obtained by reduction of the oxide with carbon or aluminium powder in an electric furnace. (See also Marden and Rich (*B.C.A.*, 1927, B, 657).)

Carnotite ranks next in importance to *patronite* as the most important ore, and is a yellow radio-active mineral of varying composition, containing uranium also, in association with lime and potash. The real carnotite is said to have the composition represented by $2UO_3,V_2O_5$. K2O+nHeO and the calcium mineral $2UO_3.V_2O_5CaO,nH_2O$. They are found in sandstone beds and worked in the south-western part of Colorado and the south-eastern part of Utah. (See Radium.)

By roasting *roscoelite* with salt and pyrites, and subsequent leaching with hot water, sodium vanadate is obtained in solution, and by adding ferrous sulphate when cold, iron vanadate is precipitated.

Vanadium is of importance in the manufacture of certain kinds of steel, a very small proportion—little more than from 0·05 to ½ per cent.—removing occluded oxygen and nitrogen, and contributing tensile strength, elastic limit, and special properties of much value for particular applications; it also finds use as a catalyst in various processes, being less susceptible to catalytic poisoning than platinum.

The metal is white, lustrous, harder than quartz, soluble in strong acids, and when heated in air burns brilliantly, forming the pentoxide (V_2O_5) (sometimes called vanadic acid), a purple-coloured body almost insoluble in water but soluble in acids and alkalies, and used as a photographic developer and catalyst. It is said to form five oxides corresponding to the oxides of nitrogen; it also forms a nitride with nitrogen, three soluble chlorides (VCl_2, VCl_3, and VCl_4), while vanadates are known corresponding to the three unknown acids HVO_3, H_3VO_4, and $H_4P_2O_7$. V

The tetrachloride, which is dark green and soluble in water, is used as a mordant in the textile industry; the oxides are insoluble in water and are used in metallurgy; and there are two sulphates (green and blue salts, soluble in water) also used as mordants. Complex vanadium silicates are used in place of platinum as catalytic agents, among other applications, for conversion of SO_2 into SO_3 in oleum manufacture.

(See A. J. Ewins (*Ind. Chem.*, 1925, i., 3); Jerome Alexander on "Vanadium and Some of its Industrial Applications" (*Chem. and Ind.*, 1929, **48,** 871 and 895); further details concerning vanadium alloys and compounds given in an article referred to in the *C.T.J.*, 1929, **84,** 119; "A Survey of the World's Resources of Vanadium Ores," by W. S. Hutchinson (*C.T.J.*, 1930, **87,** 130); and "Fused Vanadium Oxide from Rhodesian Ores" (*C.T.J.*, 1931, **89,** 197).)

"VANDYKE BROWN"—Indefinite mixtures of iron oxide and organic matter, forming the constituents of bog-earth or certain natural ochres, and used as pigments.

"VANDYKE RED" is a pigment composed of a double cyanide of copper and iron ($Cu_2Fe(CN)_6$).

VANILLA—The pods of *Vanilla planifolia* and other species of an orchid which grows wild in Mexico, Brazil, and Guiana, and is cultivated in many tropical countries; the West Indies, the French colonies of Madagascar, Réunion, Comoro Islands, and the Seychelles furnishing the principal supplies. The pods contain shining crystals of vanillin ($C_8H_8O_3$ or $C_6H_3.OHO.CH_3.CHO$) in association with a resinous body and other constituents, and have a pleasant aromatic taste and odour.

The most suitable solvent for extracting vanilla from the beans is stated to be 65 per cent. ethyl alcohol.

Vanillin is largely used in perfumery, also for flavouring purposes, and in medicine. It is prepared on a large scale from coniferin ($C_{16}H_{22}O_8 2H_2O$), which by hydrolysis yields glucose and coniferyl alcohol [$C_6H_3(OH)(OCH_3)(C_3H_4.OH)$], and the latter by oxidation gives vanillin. It is also obtained by the oxidation of eugenol, or preferably iso-eugenol (into which it is converted by heating with solid caustic potash), ozone being one of the agents employed. Further, it can be obtained from narcotine and cinnamic aldehyde and synthesized from protocatechuic aldehyde, and from guaiacol. There is also a process for its preparation from "sulphite lye" based on the lignin content of the lye (Kurschner). It is soluble in water, alcohol, and ether, has m.p. 80° C. and b.p. 285° C. Acetanilide is a common adulterant, and piperonal is also used at times. Its production from oil of cloves is described by J. McLang (*C.T.J.*, 1925, **77**, 3 and 180); and from guaiacol (*Ibid.*, **49**, 35). See also A. Wagner (*B.C.A.*, 1928, B, 664); *Ind. Chem.*, 1929, v., 279; J. Schuyzer (*B.C.A.*, 1931, B, 57); and Cloves.

VAPORIZATION—Passage from liquid to vapour form. (See Evaporation and Vapour Pressure.)

VAPOUR DENSITIES—The relative weights of gases at the same temperature and pressure compared with hydrogen as the unit, determined either by ascertaining the weight of a given volume or the volume of a given weight of vapour. These densities are in some cases (including hydrogen, oxygen, nitrogen, chlorine, bromine, iodine, sulphur, and selenium) identical with their atomic weights. The exceptions to the rule include mercury, cadmium, zinc, potassium, sodium, arsenic, and phosphorus, the first five named of which have densities one-half of their atomic weights, and the last two twice that of their atomic weights.

The general law is that the vapour densities of the elements are one-half of their molecular weights, and the explanation of the noted exceptions rests upon the theory that the molecules of mercury, cadmium, zinc, potassium, and sodium consist of but one atom, so that their atomic and molecular weights are identical, while arsenic and phosphorus contain each four atoms in their molecules, and their smallest part that can take part in a chemical change is one-fourth of their molecular weights or one-half of their densities. (See Gases, Molecules, and Valencies.)

VAPOUR PRESSURE—That exerted under equilibrium conditions while in contact with the solid or liquid generating it. It increases as the

VAPOUR PRESSURE (*Continued*)—
temperature rises, up to the boiling-point, at which it equals the atmospheric pressure. (See Evaporation.)

VAPOUR TENSION—This term expresses the tendency of liquids to pass into the state of vapour balanced by the vapour pressure.

VAREC (**Varech**)—The Normandy name for the ashes of sea-weeds. (See Barilla, Iodine, Kelp, Sea-Weeds, and Vriac.)

VARISCITE—A mineral form of hydrated aluminium phosphate ($AlPO_4.2H_2O$).

VARNISHES are solutions of resinous substances which, when spread over the surface of any object, leave behind, after evaporation of the volatile vehicle, a thin shiny layer of the dissolved bodies, and are used as protective coverings to painted wooden, iron, and other surfaces. Animé, asphalt, benzoin, copal, dammar, elimi, mastic, resin, sandarach, shellac, etc., are all used in compounding them according to the purpose of their applications, copal varnish being one of the most important. Common resin cannot be used in its original state, but is first softened by heating with lime out of contact with air, or is esterified with glycerine.

To dissolve copal and some of the other resins or gums which are practically insoluble, it is requisite to powder and subject them to a process of dry distillation (or so-called "gum-running") at a temperature of about 360° C., by which treatment they lose from 20 to 25 per cent. of their weight, but in this viscous condition can then be dissolved in turpentine and boiled or blown linseed oil. While these two liquids are used in compounding ordinary varnishes, other kinds are made using spirits of wine, petrol, turpentine, or other solvent alone or in admixture.

For the removal of impurities in suspension in ordinary varnishes (fluids of extreme viscosity) resort is had to deposition or, better still, to the use of centrifugal force, one appliance used for the purpose being the Sharples "supercentrifuge," the deposited matter being known as "foots." The same treatment gives good results for the removal of mucilage from linseed oil intended for use in varnish-making.

"Driers" are chemical materials used in oil-boiling, varnish and paint-making to facilitate the drying of the final products, and are introduced after making the varnishes and churned in. For varnish-making, manganese dioxide, cobalt and manganese resinates, oleates and borates, litharge (lead oxide) and zinc sulphate are used among others; while for paints, apart from the drying properties of any lead oxides that may be incorporated, and that of the varnish itself (when incorporated in the paints), the drying depends mainly upon the boiled or blown linseed oil used in compounding them. Driers modify the course of oxidation, the oxygen absorption being lower than that observed when they are absent, while the amount of carbon dioxide evolved is approximately the same. It is therefore concluded that driers do not act as true catalysts. The maturing of varnishes takes time, and while cheap qualities are ready in certain cases to draw off from the "foots" within

VARNISHES (*Continued*)—

a year, others of higher quality call for storage over a number of years and in certain cases subsequent filtration through a filter press.

Vanadium driers are stated to be little less efficient than cobalt driers and act much more rapidly in the initial oxidation of linseed oil than lead driers; the rapid absorption of oxygen continues for much longer, about 1·75 times as much oxygen being absorbed. (See *Chem. and Ind.*, 1928, **47,** 1147, and *C.T.J.*, 1931, **88,** 197.)

Asphalt (bitumen) is largely used in making black varnishes, and "Albertol" and other synthetic resins and other compounds have come into considerable use in the preparation of various varnishes.

Spirit varnishes consist of gum shellac or other resin dissolved in a suitable volatile solvent or mixture of solvents according to the nature of the application to be made of the products, pigments being introduced at times, and proportions of pyroxylin being sometimes substituted for the shellac or resin.

With respect to the "blooming" of varnishes, recent investigations have shown that bloom is of two forms, one being a crystalline deposit of ammonium sulphate obtained from the air, and the other a deformity of the surface brought about by certain conditions.

Insulating varnishes for coils of electrical transformers are made from a base commonly compounded of Chinese wood oil (tung oil), linseed oil, and suitable resins or ester gums, the solvents used being the higher gravity petroleum fractions or the lower ones with an added proportion of benzene (C. O. Harvey, *Chem. and Ind.*, 1926, **45,** 233).

Other References: Tests for hardness, gloss, colour, and levelling of varnishes, described by A. H. Pfund (*B.C.A.*, 1925, B, 641); article on "Enamels," by F. Singleton (*Chem. and Ind.*, 1925, **44,** 24); "Notes on Oil Varnishes and Some Representative Recipes," by J. S. Remington (*Ind. Chem.*, 1926, ii., 475); "Details of Some Drying Tests" (*Ind. Chem.*, 1926, ii., 281); article by C. E. Watson (*Chem. and Ind.*, 1927, **46,** 436 and 457); T. H. Barry on "Varnish Resins" (*C.T.J.*, 1927, **81,** 581); "The Chemist: his Place in the Varnish Industry" (*Chem. and Ind.*, 1927, **46,** 147); description of a varnish factory (*Ind. Chem.*, 1930, vi., 393); "The Present Position of the European Paint and Varnish Industry," by E. Fonrobert (*Ind. Chem.*, 1931, vii., 186); "Blooming of Varnish Films," by W. Krumbhaar (*B.C.A.*, 1931, B, 33); "Oil Varnishes for Ironwork" (*C.T.J.*, 1931, **89,** 452); *Volatile Solvents and Thinners used in the Paint and Varnish Trades,* by N. Heaton (Ernest Benn, Ltd., London); *Varnishes and their Contents,* by R. S. Morrell (Oxford University Press, London); *Colours and Varnishes,* by Ch. Coffignier (Scott, Greenwood and Sons); *Cellulose Ester Varnishes,* by F. Sproxton (Ernest Benn, Ltd., London); also "Albertol," Dopes, Gums, Lacquers, Linseed Oil, Nitro-cellulose, Paints, Plasticizers, Pyroxylin, and Resins.

"VASELINE"—The trade mark of proprietary products consisting largely of petroleum jelly (which see).

VAT DYESTUFFS—See Dyes.

VEGETABLE BLACKS—Carbon pigments from various sources. (See Bone Black, Carbon, Ivory Black, and Lamp Black.)

VEGETABLE IVORY (Tagua Nut)—The kernels of the *Phytelephas macrocarpa* tree which grows in Peru, Colombia, and other parts of South America. The substance of these nuts has the appearance of ivory and is very hard, but can be turned in the lathe, and is used for making buttons, umbrella handles, and trinkets. By treatment with dilute sodium hydroxide it yields a substance named mannan, which is related to the cellulose group of chemical compounds. (See Mannose.)

VEGETABLE MATTERS—See Carbon, Photo-catalysis, Plant Colouring Matters, Soils, and Vegetation.

VEGETABLE OIL SEEDS—See Oil Cakes.

VEGETABLE OILS AND FATS—See Fats and Oils.

VEGETABLE TALLOW (Chinese) is the white waxy substance found as a covering on the fruit of *Stillingia seberifa* (N.O. Euphorbiaceæ), cultivated in Hupeh, Szechwan, Hunan, Kiangsi, and Kweichow provinces, also Japan. The tallow tree is described otherwise as a member of the Spurge family (*Sapium sebiferum*) and is said to grow to a height of from 40 to 50 feet. The tallow of the "prima" quality has a m.p. of 36° to 47° C., sp. gr. 0·8843 to 0·904, sap. v. 206, i.v. 19·37 to 60·76, and is used for candle and soap making.

The pale yellow oil expressed from the seeds, after steaming them to remove the exterior fat, amounts to about 19·2 per cent.; it is known locally as *ting-yu*, or *tze yu*, has an odour like that of linseed oil, and constitutes the Stillingia oil of commerce, having a sp. gr. of about 0·873, sap. v. about 200, and i.v. about 160. The so-called "secunda" vegetable tallow is a mixture of the two things obtained from the seeds without first removing the exterior tallow, and, like the tallow, is used for candle and soap making, also as a lubricant and for dressing textiles in common with the Stillingia oil. Various mixtures are offered commercially, and it is stated that other varieties of fat are extracted from the trunk and bark of the trees, known as *o'chia*.

The refuse of the seed is said to be a valuable tobacco-plant manure, while the bark of the tree is used in medicine, and the leaves furnish a black dye.

The component glycerides of this tallow are described by Hilditch and Priestman (*J.S.C.I.*, 1930, **49,** 397 T), the fatty acids contained being chiefly palmitic 57 to 69 per cent. and oleic 21 to 34 per cent.

VEGETABLE WAX (Japan Wax)—See Waxes.

VEGETATION—The chemical processes involved in vegetable life are only comparable to those concerning the animal organism, are of the same general order, and can be to some extent controlled or modified by external influences. For instance, plants can transform saligenin, benzyl alcohol, and vanillin into glucosides, the first named of these substances becoming converted into salicin; and nicotine in tobacco can be increased by the introduction of dextrose and so forth.

There is good reason for the view that plants are possessed of a nervous system, which appears to have been localized to some extent

VEGETATION (*Continued*)—

by J. C. Bose, first by the electric probe, and secondly by selective staining.

It is recognized that calcium, magnesium, sodium, sulphur, iron, phosphorus, and potassium are requisites for perfection in growth, and many other chemical elements, when present in small amounts, exercise a stimulating or other beneficial effect, being in some cases essential; while silica assists plants to withstand the attacks of moulds and parasites, and exhibits a capability of increasing growth and modifying the physical nature of plant tissues. (See D. R. Nanji and W. S. Shaw on "The Rôle of Silica in Plant Growth" (*J.S.C.I.*, 1925, **44,** 1 T).)

Fed only upon water, the soil and atmospheric constituents, the list of vegetable products is arrestingly wide and wonderful. In addition to the cellulosic compounds constituting the cells and vessels, there are the wide ranges of colouring matters and odorous principles; the various alkaloidal bodies, such as aconitine, quinine, and morphine; series of gums, resins, fixed oils, fats, starches and sugars; a still wider category of essential oils and other volatile principles; and innumerable chemical products having medicinal or commercial value. All these products are built up synthetically by the chemical agencies (life-action) of the nitrogenous protoplasm of plant life from water, nitrogen, the carbon dioxide absorbed from the soil and air by their roots and other parts—*stomata* or small openings on the lower surfaces of leaves—with the co-operation of other soil constituents and varying atmospheric influences, including light and heat.

On average, dried vegetables weigh about one-tenth of the raw materials, and are used in the preparation of soups and otherwise as food. (See "The Drying of Vegetables," by A. W. Knapp (*J.S.C.I.*, 1926, **45,** 123 T), and description of Colonel Lyon's method of drying grass and crops (*Country Life,* August 4, 1928).)

Vegetation has an important bearing upon the health of communities, as, apart from the capacity of plant life for absorbing carbon dioxide from the air and restoring oxygen thereto (see Carbon and Air), trees absorb from the soil a great deal of water, which for the most part is subsequently evaporated into the air from the surfaces of the leaves, so that many malarious districts can be made drier and more healthful by means of plantations. Again, many plants and trees give off the vapours of essential oils into the air, and thus exercise a beneficial effect due to their balsamic character and the subsequent production of hydrogen dioxide by the action of the air and moisture upon these oils. Vegetation also assists in the purification of polluted waters and soils by the chemical assimilation of their organic constituents.

The growth of algæ in the sea in springtime is attributed to the light that penetrates, preceding the rise of temperature, the curve of growth closely following that of sunshine, and is accompanied by an increase in alkalinity of the water. Higher plants keep a supply of alkali in their tissues, and use it repeatedly for fixing free carbon dioxide.

It would appear that the synthesis of sugar (hexose) in the green leaves of plants takes place in ordinary daylight through the inter-

VEGETATION (*Continued*)—

mediate formation of formaldehyde from carbon dioxide and water (present in the air and soil) under the photocatalytic influence of chlorophyll contained in the chloroplasts of the protoplasm.

Under the influence of sunlight, algæ use nitrites and nitrates in building up nitrogenous compounds, and the green cells of plants synthesize from atmospheric constituents their proteins, fats, and carbohydrates. It has been experimentally demonstrated that in the absence of carbon dioxide, plants are able to restore their stock of carbohydrate direct from formaldehyde when supplied for that purpose.

As a rule, plants obtain what nitrogen they require from ammonia and nitrates in the soil, the ammonia for the most part coming from products of organic decay; but some leguminous plants, such as peas, beans, vetches, and the indigo plant, assimilate nitrogen direct from the air by some action of bacteria situate in nodules which form on the rootlets of these plants. There is also some evidence for the belief that the cells of the green leaves of wheat and barley gain nitrogen in elementary form from the air, while peas seem unable to do this. By intensifying the nitrogenous value of pastures by the scientific application of fixed nitrogen it is anticipated that their stock-carrying capacity and output of milk or meat may be greatly increased.

(See T. H. Fairbrother (*Ind. Chem.*, 1927, iii., 73, 113, 174, 201, and 319); "Power Alcohol from Vegetable Waste" (*C.T.J.*, 1927, **81,** 532; *Ind. Chem.*, 1927, iii., 526); *Lecture on Modern Applications of Chemistry to Crop Production,* by E. J. Russell (Inst. of Chem.); Reports of Rothamsted Experimental Station (Secretary, Harpenden); "High Protein Pasture" (close grazing), by F. T. Shutt (*Chem. and Ind.*, 1930, **49,** 679); "Seasonal Variations in Composition of Pasture, etc." by Hall and Hargrave (*J.S.C.I.*, 1931, **50,** 167 T); "The Recent Applications of Science to Agriculture," by Sir Daniel Hall (*Chem. and Ind.*, 1931, **50,** 862); *The Chemical Investigation of Plants,* by L. Rosenthaler, 3rd edition (G. Bell and Sons, Ltd., London); *Chemistry of Plant Products,* by Haus and Hill (Longmans, Green and Co); *Plant Biology,* by H. Godwin (Cambridge University Press); *The Principles of Plant Biochemistry,* Part I., 1931, by M. W. Onslow (Cambridge University Press); *Plant Products,* by S. H. Collins and G. Redington (Baillière, Tindall and Cox, London); Baillière's *Encyclopædia of Scientific Agriculture,* edited by H. Hunter (Baillière, Tindall and Cox); *Research and the Land,* by V. E. Wilkins (H.M. Stationery Office); also Air, Bacteria, Chlorophyll, Di-Nitro-Chloro-Benzene, Fertilizers, Nitrification, Plant Colouring Matters, Photocatalysis, and Soils.)

VEGETO-ALKALOIDS—See Alkaloids.

VELINIUM—Name of a substance regarded as a newly discovered element intermediate between neodymium and samarium, but known, so far, in very minute quantity.

VENETIAN RED—A pigment and polishing-powder, consisting of ferric oxide, made from red hæmatite or by calcining ferrous sulphate.

VENICE TURPENTINE—See Turpentine.

VENTILATION—Discomfort and headache are caused when oxygen in the air is diminished by even 1 per cent., and asphyxia results when carbon dioxide present in tidal air reaches 10 per cent. Huxley was of opinion that every man should have a breathing space of 800 cubic feet to be adequately supplied with pure air, and it has been calculated that each adult consumes 1½ lbs. of oxygen daily, measuring at ordinary temperature and pressure about 117 gallons (529,400 c.c.).

(See "The Removal of Steam and Vapours from Factory Atmospheres," by H. Winter (*Ind. Chem.*, 1929, v., 457); report by H. Vernon and others (Special Report Sheet, No. 100, Medical Research Council, Adastral House, Kingsway, W.C. 2); apparatus for the detection of air movement, by R. C. Frederick (*Analyst*, 1925, **50**, 399); R. C. Frederick on "Ventilation Conditions" (*Analyst*, 1925, **50**, 213); and lecture by the same author (Inst. of Chem.); also Air and Respiration.)

VENTZKE DEGREES are referable to a determination of the sucrose or cane-sugar content of a solution made by means of a polariscope, the scale being so graduated that the amount is read off direct. When the normal weight of 26·048 grms. of sucrose is dissolved in 100 c.c. of solution in a 200 mm. tube, the degree registered is 100 and so on.

VERATRINE (**Cevadine**)—This is really a mixture of alkaloids obtained from sabadilla (cevadilla)—the dried ripe powdered seeds of *Schœnocaulon officinale,* growing in Mexico, Guatemala, and Venezuela—by exhausting with alcohol. The chief alkaloid is cevadine ($C_{32}H_{49}NO_9$) (veratrine) of m.p. 205° C., readily soluble in alcohol, and it is accompanied with veratridine ($C_{37}H_{53}NO_{11}$). Cevadine is a white, crystalline body of extremely poisonous character, soluble in alcohol and ether, and is used medicinally as an antifebrile agent. Veratrine sulphate $(C_{32}H_{49}NO_9).H_2SO_4$ is soluble in water and is also used in medicine. (See Sabadilla.)

VERATRUM—The dried rhizome and roots of *Veratrum viridis*; used in medicine. (See Delphinine and Hellebore.)

VERBENA OIL (sp. gr., 0·900 to 0·918 at 15° C.; rotation, $-8°$ to $-16°$ at 20° C.) is distilled to the extent of up to 2 per cent. from the leaves of *Verbena triphilla* (N.O. Verbenaceæ), grown in France and Spain, and contains from 20 to 38 per cent. of citral. It is used in perfumery and for flavouring, and should not be confounded with lemon grass oil. The lemon-scented oil is said to be obtained from *Aloysia citriodora* and the perfumer's variety from the lemon grass. (See Citronella Oil and Lemon Grass Oil.)

VERDIGRIS—See Copper, p. 238.

VERJUICE—See Vinegar.

VERMIFUGES—See Insecticides.

VERMILION—The manufacture of this compound is a notable industry in Hong-Kong, the article being used by the Chinese in varnish-making, for colouring candles and paper, and for stamping and writing purposes. (See Cinnabar and Mercury (Sulphide).)

"VERMILION SUBSTITUTE"—A preparation which has largely supplanted mercuric sulphide, consisting of about 95 per cent. red-lead (Pb_3O_4) coloured with eosin (tetrabromo-fluorescin, $C_{20}H_8Br_5O_5$)—a red, crystalline, organic dye. (See Eosin.)

VERMOUTH—An alcoholic beverage with a basis of white wine. The Italian variety is made from super alcoholized muscatel wine, sweetened with sugar, to which wormwood, gentian, and extracts of other bitter herbs are added to lend special flavour; while the French product is similarly made, using the driest white wine that is procurable. (See Absinthe and Wormwood.)

VERONAL—See Barbitone.

VESUVIAN (**Vesuvianite, Idocrase**)—A crystalline mineral varying in colour from brown to green, consisting in the main of calcium-aluminium silicate, occurring in dolomitic rocks, limestone, serpentine, gneiss, etc.; crystal system, No. 2, and sp. gr. about 3·4.

VETIFER OIL (**Verti-Vert Oil, Cuscus Oil**), distilled (0·2 to 3·5 per cent.) from the roots of the cuscus grass, known as *Vetiveria zizanioides*, found in Ceylon, West Indies, Brazil, Mysore, Bengal, Burma, etc. It is a thick, yellowish-brown oil of violet-like odour, containing sesquiterpenes; soluble in alcohol, ether, etc.; of sp. gr. about 1·0 to 1·030, op. rot. +25° to +38° at 20° C., and ref. ind. 1·517 to 1·520 at 20° C. The oils of various origin are used in perfumery; they differ somewhat in their physical characters, and baskets, fans, and mats are made from the grass tissue.

"VIBRAC"—A nickel chrome steel of exceptional strength, said to have the property of never tempering brittle, of great elastic limit, very consistent, and largely adopted for aeroplane and automobile work.

VIBRATORY PLANT—See Sifting.

VINASSE—The residue left after fermentation of beet molasses, containing potassium salts and some nitrogenous matter, which qualify it for use both as a fertilizer and cattle food. (See Molasses and Sugar.)

VINEGAR is a preparation of acetic acid, of which it contains a legal minimum of 4 per cent. The ordinary English variety is made, in part, by the method referred to under Acetic Acid, and otherwise as described below under Malt Vinegar, the British production being estimated at 25 million gallons per annum. In Germany and France it is made from wine by exposure to the air in casks containing some beech-shavings or by mere exposure to the air in sunlight; in the U.S.A. cider or apple vinegar is preferred. Orange juice can also be employed, in which case the product contains some citric acid. Small proportions of alcohol and furfurol are found present at times. All are made from alcoholic liquids by agency of certain organisms (or their enzymes), including the *Bacterium aceti, B. Pasteurianum, B. xylinus, B. Kützingianum,* and *B. acetigenus*. (See Pyroligneous Acid.)

Malt Vinegar is prepared from malt or malt and raw barley mashed as in brewing, and then submitted to vinous fermentation and subsequently soured as already described.

VINEGAR (*Continued*)—

Distilled Vinegar is any variety of vinegar submitted to distillation, so that it is thereby deprived of its colouring matter.

Balsam Vinegar—So-named "Balsam" vinegar was originally made from a mixture of strong must from the white Trebbiano grape with strong ordinary vinegar by storage in wooden casks for many years up to a century. A fairly good balsam vinegar is now made by adding old vinegar to boiled must. (See H. von Loesecke (*Ind. Eng. Chem.*, 1929, **21**, 175) and E. Parisi (*B.C.A.*, 1928, B, 941).

Banana Vinegar is made from the pulp and peel of the ripe fruit containing some 16 per cent. fermentible sugars. The mash is pasteurized at 75° for forty-five minutes and inoculated when cold with *Saccharomyces ellipsoideus*, etc. (See H. Von Loesecke, *B.C.A.*, 1929, B, 449.)

Tomato Vinegar is vinegar flavoured with an infusion of tomatoes, or tomatoes may be added to the alcohol or wine before acetification. (See Acetic Acid, and *Vinegar: Its Manufacture and Examination*, by A. Ainsworth Mitchell (C. Griffin and Co., London).)

Verjuice is vinegar made variously from the juices of crab apples, unripe grapes, and sour cider.

VINYL ALCOHOL (Ethenol CH : CH.OH) occurs in commercial ether, but not yet isolated; allied compounds have been used in making a new class of synthetic resins. (See *C.T.J.*, 1931, **89**, 153, and 1932, **90**, 206.)

"VIOFLOR"—A proprietary preparation for deodourizing white spirit, turpentine substitutes, etc., stated to consist of a combination of volatile aromatic hydrocarbons.

VIOLET ESSENCE—See Ionone and Orris Oil.

VIRUSES—Poisons intimately concerned with infectious and contagious diseases. (See H. H. Dale (*Chem. and Ind.*, 1931, **50**, 827); Albumins, Bacteria, Biochemistry, Toxins, and Vaccines.)

VISCOGEN—Calcium saccharate.

VISCOID—See Silk Substitutes, p. 812.

VISCOSE—A prepared form of cellulose for the manufacture of silk substitutes. (See Silk Substitutes.)

VISCOSIMETER (**Viscometer**)—See Lubricants, Oils, and Viscosity.

VISCOSITY—The term viscosity means the resistance shown by a fluid to flow, and it is measured by the tangential force or unit area of either of two horizontal planes at unit distance apart, one of the planes moving with unit velocity relative to the other, the space between being occupied with the flowing fluid.

The C.G.S. unit (centimetre-gramme-second system of physical units) is that of a fluid in which the tangential force per sq. cm. exerted on each of two parallel planes 1 cm. apart in the fluid is one dyne, when one of the planes is moving with a velocity of 1 cm. per second in its own plane relatively to the other

VISCOSITY (*Continued*)—

In plain terms, the viscosity or resistance to flow of a colloid or other solution is ascertained by measuring the time of outflow from a standard volumetric pipette; roughly expressed, the viscosity is inversely proportional to that time. The viscosity of oils and greases, which, of course, largely depends upon the temperature, is determined in much the same way, or by the time taken, under standardized conditions, for a metallic bulb to fall through a measured column of the substance under examination. With respect to this method as applied to opaque solutions when the ball cannot be seen, a new device has been introduced (see Symmes and Lantz, *Ind. Eng. Chem.*, 1930, p. 35) to overcome this difficulty. (See also F. Geiger respecting the Tausz falling-ball viscometer (*B.C.A.*, 1931, B, 524).)

Viscosity diminishes as temperature rises, and increases to some extent as pressure rises. The B.E.S.A. have issued a revised specification in respect of the determination of viscosity in absolute units. According to D. B. Macleod, the viscosity of liquids is inversely proportional to the free spaces within them, and is to be interpreted as a simple function of the molecular weight.

The "Redwood," "Saybolt," and "Engler" viscometers are the best-known types for determinations of the one class, whilst the "Michell" viscometer shows advantages in respect of the other or "falling-ball" type. It is also reported that the "plastometer" (see Plastometer) and the "MacMichael" and "Doolittle" torsional viscometers are the only reliable instruments for determining the viscosities of varnishes. The "Stormee" and "Ostwald" viscometers are other types.

Other References: A simple viscometer for use with enamels (*Ind. Chem.*, 1925, i., 505); "The Estimation of Viscosity," by W. M. Seaber (*Ind. Chem.*, 1926, ii., 243); a novel viscometer described as an improvement on the "Ostwald" (*Ind. Chem.*, 1926, ii., 375); another new viscometer (*Ibid.*, ii., 501); "A New Method of Measuring Viscosity at Higher Temperatures," by H. H. Mercer (*J.S.C.I.*, 1926, **45,** 203 T); R. O. Boswall (*B.C.A.*, 1927, A, 463); R. H. Van Linge (*B.C.A.*, 1929, A, 785); a new pipette viscometer by J. Romney (*Chem. and Ind.*, 1930, **49,** 986); an improved simple viscometer by A. E. Robinson (*Ind. Chem.*, 1929, v., 205); an oil viscometer by H. Schaffer (*B.C.A.*, 1930, B, 1095); "The Kämpf Viscometer," by E. Landt (*B.C.A.*, 1931, B, 465); R. W. Kinkead (*Analyst,* 1931, **56,** 692); "Determination of the Viscosity of Tar, Pitch, etc.," by Broome and Thomas (*J.S.C.I.*, 1931, **50,** 424 T); *A Monograph of Viscometry,* by Guy Barr (London: Humphrey Milford, 1931; Oxford Univ. Press); and *The Viscosity of Liquids,* by E. Hatschek (G. Bell and Sons, Ltd.).

"VITAMINA"—A German product of yellow colour, described as a vitamin-producing substance, prepared from the soya bean, composed approximately of 75 per cent. phosphatic bodies (lecithin constituting one-half), 20 per cent. fat, and 5 per cent. phytosterine, water, etc., for addition to margarine, chocolate, cocoa, and other foods deficient in vitaminic character. (See *C.T.J.*, 1926, **79,** 565.)

VITAMINS (Accessory Food Factors)—The name given to certain substances present in some living tissues and other materials, including butter and cod-liver oil, but absent from lard, nut and seed oils after they have been hydrogenated. In butter they are contained in the less crystallizable part known as butter oil. Vitamin A is volatile, passing over on distillation between 180° to 220°/2 to 3 mm.; soluble in fat solvents, promotes growth and prevents rickets. It is described as a pale yellow oily body (possibly an alcohol) derived from carotene ($C_{40}H_{56}$), and formulated $C_{20}H_{30}O$; that is to say, half a molecule of carotene in combination with 2 atoms of hydrogen and one of oxygen. Other varieties of this type are labelled D_1, D_2, and E; the D varieties (oil soluble) being regarded as concerned with bone formation and anti-rachitic factors, and E as an anti-sterility factor. Another (B) is described as soluble in water but not in fat solvents, and a third (C), unstable in character, soluble both in water and alcohol. It has been found that the active materials present in vegetable oils can be concentrated in the sterol fraction, and that the sterols from animal fats exhibit some of the characters of the parent substance of vitamin D, now known to be a direct product of the irradiation of ergosterol and commercially available under the name of "Calciferol" in crystalline form resembling (according to F. A. Askew) D_2.

A method for the artificial production of vitamin D consists in manufacturing ergosterol from yeast or fungi and exposing it to radiations of wavelength about 2,700 to 3,000 Angström units in the absence of oxygen (Carr (*J.S.C.I.*, 1928, **47**, 252 T) and Moore and De Vries (*J. Amer. Chem. Soc.*, 1931, **53**, 2676). The name of "Viosterol" has been given by the Council on Pharmacy and Chemistry of the American Medical Association to preparations of irradiated ergosterol.

A. Windaus gives the formula of $C_{27}H_{42}O$ to vitamin D_1, m.p. 124° to 125° C., and m.p. 114° to 115° C. to D_2.

Two Japanese investigators claim to have isolated vitamin A from cod-liver oil, the yield being about 1 per cent., and described by them as a hygroscopic aldehyde without any nitrogen content, while the vitamin A fraction of the unsaponifiable portion of cod-liver oil is otherwise said to consist largely of unsaturated alcohols of high molecular weight. The carrot is stated to be almost as rich in vitamin A as cod-liver oil. (See Plant Colouring Matters (Carotene).)

There are few chemical methods at present known for the detection or estimation of these substances, reliance being largely dependent upon biological methods. They are supposed to have great influence in the promotion of growth, as, although existing in very small amounts, they exercise an influence like that of enzymes in converting what would otherwise be non-efficient dietaries into efficient ones.

Baly has suggested that possibly vitamins owe their value, not to their chemical composition, but rather to their being repositories of high potential energy, a suggestion which is supported by the activating influence of ultra-violet light upon many materials, giving to them, for example, anti-rachitic activity. (See Ultra-Violet Rays.)

VITAMINS (*Continued*)—

They are regarded as exercising a drug-like specific stimulation of certain parts of the digestive tract, which in their absence undergo a kind of atrophy, in this respect resembling hormones. Diets may be perfectly wholesome and well digested, but unless the food is associated with a proper proportion, small as it is, of vitamins derived from living cells of plants or animals, the nutrition, particularly of the nervous system, is defective. The suggestion has been made that the action of vitamins in foods is to be ascribed to the permeability of the walls of the intestine to colloids and substances of high molecular weight due to the high surface activity of substances in the vitaminoid state (F. V. von Hahn, *J.C.S. Abs.*, 1925, II., 664). In any case, they are only to be regarded as part of, or contributory to, a well-balanced dietary.

The fresh juices of edible parts of the orange, lemon, and grape-fruit are said to contain the water-soluble B vitamin, equivalent, volume for volume, with cow's milk, grape-juice being inferior in this respect; and the edible parts of apples and pears furnish some quantity, but are not rich in this respect, while prunes are somewhat richer, and yeast extract is richer still.

Butter, lard, palm, yellow maize, and cotton-seed oils apparently contain appreciable amounts of the A fat-soluble, growth-promoting substances, and cabbages and potatoes both contain fat-soluble factors, which can be extracted by alcohol, raw cabbages being particularly rich. The vitamin occurring in animal fats, such as lard, is stated to be readily destroyed by oxidation—as, for instance, by exposure to the air. Crude unrefined cod-liver oil is said to be 250 times as potent as butter, whilst swedes, apples, and orange juice are rich in the antiscorbutic vitamin (C), stated by Otto and associates to be derived from narcotine, and which is most stable in acid solutions. Soldiers or sailors who for long periods are unable to obtain supplies of fresh foods are liable to scurvy, and this disease can be prevented by the sufficient use of fresh meat and vegetables and of orange and lemon juices, all of which contain this vitamin. It is stated to be very sensitive to alkaline reaction, and completely destroyed by heat, unless associated with an acid which greatly protects it in this respect, so that the tomato, for instance, is antiscorbutic even after canning.

Dried seeds are generally deficient in A substance, the formation of which in green leaves is thought to be closely dependent on the presence of chlorophyll, and to be formed by the agency of light.

Sun-dried tomatoes, potatoes, and cabboge retain the antiscorbutic properties of the fresh vegetables to a large extent, whereas sun-dried carrots, spinach, turnips, and turnip-tops contain little or none.

Yeast is rich in the vitamin B, which is possibly of plural nature (see Hogan and Hunter (*Analyst*, 1928, **53,** 505) and H. Chick (*Chem. and Ind.*, 1930, **49,** 769)), and is said to prevent development of certain nervous disorders and scurvy. The disease known as beri-beri, which is endemic in Japan, the Malay Peninsula, and the Dutch Indies, has been attributed to the habit of feeding too exclusively upon polished rice,

VITAMINS (*Continued*)—

due to the removal of the constituent water-soluble B vitamin associated with the "silver skin" of the seed, and which is unfortunately removed by the milling process now prevalent for polishing the rice. This vitamin is stated to be least affected by the commercial preparation and cooking of foodstuffs containing it, and experiments have shown that storage for nine years at a temperature of −17° to −9° C. does not destroy nor affect it as contained in meats; while the A and C varieties, although fairly stable (as contained in foodstuffs) when exposed to 100° C. (or in case of A to 120° C.), are readily inactivated by exposure to air at these temperatures, and A and D are stated to be decomposed by light.

In the Federated Malay States a preparation of "Vitamin B Extract" from rice polishings is now being made.

Bashir Ahmad has expressed the opinion that the vitamin A activity of vegetable sources is carotene, and that it essentially differs from that of the fish-liver oils (*J.S.C.I.*, 1931, **50,** 14 T); and the work of Euler (with others) has led to the view of its constitution as expressed on p. 959.

One of the vitamins (A) in fish oils is stated to have been traced back to the synthetic powers of the marine algæ, which form the fundamental food supply of all marine animals.

A concentrate of vitamin A can be obtained from cod-liver oil in the unsaponifiable fraction if precautions are taken to prevent oxidation, and larger quantities from the liver fats of the sheep, calf, and ox, and it has been demonstrated that the active principle is volatile under steam distillation or high vacuum distillation, and is free from nitrogen, iodine, sulphur, and phosphorus. Vitamin A has an anti-infective character, not shared by the variety D, which is not supposed to be possessed of any power of increasing the germ-killing action of the blood, but exercises a useful influence concerning calcium metabolism of the body resulting in the hardening of teeth and the bony structure of the body.

The designation of vitamin D has been applied to the antirachitic factor which is said to exist in cod-liver oil, some other fish oils, and butter, and the same term has been applied to the growth factor (known also as "Bios"), which is described as the activating substance of yeast. Vitamin D has also been found by Rosenheim and Webster in the stomach oil of the Fulmar Petrel or Australasian mutton bird (*Fulmaris glacialis*). (See *Biochemical Journ.*, vol. 21, no. 1, 1927.)

In recent publications, so-called Bios I., as obtained from tea-dust, is stated to be identical with inactive inositol (E. V. Eastcott, *B.C.A.*, 1929, A, 472); see also E. M. Sparling (*B.C.A.*, 1929, A, 472) and Peskett and O'Brien (*Chem. and Ind.*, 1930, **49,** 517).

Egg-yolk, milk, butter, cabbages, potatoes, edible pulses, spinach, yeast, and the germs and cells of cereals are all good vitamin-carrying foods when fresh. It is reported that by administration of vitamins to stock, as by the use of fresh green lettuce leaves, a sharp restoration to fertility is induced.

Relative amounts of antiscorbutic vitamins are measured by deter-

VITAMINS (*Continued*)—

mining how much of the food under test is required to prevent scurvy in guinea-pigs.

Morton and Heilbron proved by spectographic means that cholesterol is not the precursor of vitamin D, while Olcott and McCann viewed carotene as a precursor (*J. Biol. Chem.*, 1931, **94,** 185).

Experiments by J. C. Drummond and others pointed to the production of a vitamin from a definite chemical substance, and it appears that ergosterol (which is contained in yeast, ergot, and certain other fungi) by exposure to ultra-violet light rays of from 2,600 to 2,800 Angström units loses its crystalline character and becomes 200,000 times as active, weight for weight, as cod-liver oil as an antirachitic agent. Since then, as we have seen, ergosterol has been established as a parent substance of vitamin D. It is also reported that two American scientists, C. E. Bills and F. G. McDonald, have effected the synthesis of this vitamin in less powerful form from ergosterol without the aid of irradiation by treatment with methyl alcohol, ether, and ethyl acetate under low temperature and rigid exclusion of oxygen (*The Times*, January 1, 1932).

The following table is taken from a paper by S. Dixon (*Chem. and Ind.*, 1930, **49,** 645 and 663):

Vitamin.	Distribution.	Properties.
A	Liver fats from various herbivorous animals, fish-liver oils, milk, butter, cream; many green vegetables; absent from vegetable oils.	Growth promoting. Anti-infective. Prevents xerophthalmia.
B_1	Seed-germs, yeast, egg-yolk, nuts, and many green vegetables.	Anti-neuritic.
B_2	*Vide* B_1.	Growth promoting; prevents pellagra.
C	Most fresh fruits and vegetables.	Prevents scurvy.
D	*Vide* A, with exception of liver fats of herbivorous animals.	Prevents rickets.
E	Wheat germ oil and certain green vegetables—*e.g.*, lettuce and peas. Absent from cod-liver oil.	Prevents sterility.

Surveying the whole knowledge concerning this subject, it may be said that the vitaminic (vitaminous) or vitalizing characters possessed by various foods are dependent upon the presence of normal constituents constituting a natural property, and can be increased in many cases by exposure to ultra-violet light or other treatment, in much the same sense that elements like chlorine, nitrogen, and hydrogen can be activated by external means. Possibly they exercise a similar influence to that of enzymes, and, in any case, they are chemical bodies susceptible of chemical change and not to be regarded as otherwise mysterious substances.

Other References: J. C. Drummond on "Oils and Fats" (*Chem. and*

VITAMINS (*Continued*)—

Ind., 1926, **45**, 994); R. A. Morton (with others) on "Vitamin D and its relation to Ergosterol" (*J.C.S.*, 1927, p. 2000); Rosenheim and Webster (*Lancet*, 1927, **213**, 622-625); "A Standard for the Antirachitic Vitamin D" (*Chem. and Ind.*, 1930, **49**, 725); *Analyst*, 1930, **55**, 692; Coward (with others) on "A Quantitative Method for the Biological Estimation of Vitamin A" (*Chem. and Ind.*, 1930, **49**, 850); J. M. Gulland on "The Relation of Carotene to Vitamin A" (*Chem. and Ind.*, 1930, **49**, 839), and N. S. Capper (with others) (*Ibid.*, 1931, **56**, 473); J. C. Drummond (*J.S.C.I.*, 1930, **49**, 1 T); F. A. Askew (with others) on "Distillation of Vitamin D" (*Proc. Roy. Soc.*, 1930, B, **107**, 76-100); *Chem. and Ind.*, 1930, **49**, 180; T. M. Heilbron on "Present Knowledge of the Fat-soluble Vitamins A and D" (*J. Inst. Chem.*, February, 1930); Bashir Ahmad (*J.S.C.I.*, 1931, **50**, 12 T); Drummond and Ahmad (*Chem. and Ind.*, 1931, **50**, 441); Rosenheim and Starling (*Chem. and Ind.*, 1931, **50**, 443); Heilbron and Morton on "Characterization of Vitamin A," Part I., and Ahmad and Drummond, Part II. (*J.S.C.I.*, 1931, **50**, 183 T); Heilbron, Heslop, Morton, and Drummond on "Vitamin A Preparations" (*Chem. and Ind.*, 1932, **51**, 164); Smith and Zilva on "Alleged Synthesis of Vitamin C" (*Chem. and Ind.*, 1932, **51**, 166); Karrer (with others) (*Analyst*, 1932, **57**, 185); F. A. Askew (with others) (*Nature*, 1931, **128**, 758); A. Windaus (*B.C.A.*, 1931, A, 1464); *Chem. and Ind.*, 1931, **50**, 983, and 1932, **51**, 59 and 70; "Vitamin Standards" (*Analyst*, 1932, **57**, 173); *The Vitamins*, by Sherman and Smith, 2nd edit. (The Chemical Catalog. Co., Inc., N.Y., 1931).

"VITREFLEX"—Anticorrosive iron and steel building material made by application of a flexible and adherent enamel to a copper-containing iron or steel fired on at a high temperature; impervious to moisture and unaffected by temperature changes, marine, acid, and other corrosive atmospheres.

"VITREOSIL"—See Glass.

VITREOUS—Glassy. (See Glass.)

VITRIOL or OIL OF VITRIOL—Strong sulphuric acid. (See also Blue Vitriol and Green Vitriol.)

VIVIANITE—A mineral ferrous phosphate ($3FeO.P_2O_5.8H_2O$), of crystal system, No. 5, and sp. gr. about 2·6.

VOLATILE—Light, ethereal; easily passing from liquid to gaseous state.

VOLT—See Electricity, p. 298.

VOLTAIC CURRENT—See Electricity, p. 289.

VOLTAMETER (Coulometer)—Apparatus for measuring the strength or quantity of electric current passing through a circuit. Some types are based upon the electrolysis of liquids—water, for example, acidulated with a little sulphuric acid—and measuring the gases (oxygen and hydrogen) evolved. In other cases, the determination is made by ascertaining the quantity of metal deposited at the cathode from solutions exposed to the current. (See Coulometer and Eudiometer.)

"VOLTOL" OILS—Oils such as rape and marine animal oils, thickened by blowing, followed by electrical treatment (the high viscosity thus secured being due to oxidation and polymerization), and used amongst other applications for admixture with mineral oils as lubricants in the place of castor oil. Exposure of fatty oils to the electric glow discharge in hydrogen gas at low pressure yields polymerized products of high viscosity; thus, oleic acid gives about 16 per cent. of stearic acid, and when other gases, such as nitrogen, carbon dioxide, or air, are substituted, the hydrogen necessary for the reduction comes from the oleic molecule itself.

The production of high viscosity oils from those of low viscosity by agency of the silent electrical discharge ("Voltolisierung") is carried on industrially in Germany. (See *C.T.J.*, 1928, **83,** 161, and K. Wolf (*B.C.A.*, 1929, B, 232).)

The following information is taken from the *Chemical Age* (December 11, 1920):

	Sp. Gr.	Refractive Index at 15° C.	Viscosity at 100° C.	Acid Number.	Iodine Number.	Mean Molecular Weight.
Rape voltol	0·9740	1·485	83·6	11·7	52	1200
Whale voltol	0·9819	1·485	74·9	15·4	51	1000

The high viscosity of "voltol" oils is attributed in part to the contained oxidation products and polymerization induced by the blowing, but chiefly to the production of di-molecular glycerides under the influence of the electric discharge, thus accounting for their high molecular weights.

VOLTOLIZING ("VOLTOLISIERUNG")—See "Voltol" Oils.

"VOLTOLÖLE"—Lubricating oil having a specially flat viscosity-temperature curve, highly suitable for internal combustion engines; prepared from mineral oil by subjection to the action of a glow discharge, thus converting it into highly viscous material.

VOLUME (Critical)—The critical volume of a fluid is its specific volume in its critical state, or that occupied by 1 gram at the critical temperature, that of carbon dioxide being 3·34 c.c.

VOLUME OF CONSTITUENTS OF MIXTURES—A method for determining these and other factors forms the subject of a brochure by Frank L. Teed (H. K. Lewis and Co., Ltd., London).

VOLUMETRIC ANALYSES—Methods for determining the amounts of chemical substances present in solutions by the employment of reagents of definite strength in connection with well-understood interactions. "Normal standard solutions" contain an equivalent weight (gramme equivalent) of the substance dissolved in 1 litre (1,000 c.c.), and decinormal solutions are of one-tenth that strength. Thus a normal solution of hydrochloric acid contains 36·50 grammes per litre. To determine, for example, the amount of free iodine that may be contained in an acidified solution of potassium iodide, a standardized solution of

VOLUMETRIC ANALYSES (*Continued*)—

sodium thiosulphate is employed—that is to say, a solution of predetermined strength—and this is gradually run into the subject mixture from a burette until the colour has entirely disappeared. It is then easy to calculate from the known chemical interaction that takes place, the amount of free iodine in the mixture. This interaction is represented as follows: $I_2 + 2Na_2S_2O_3 = 2NaI + Na_2S_4O_6$; that is to say, the free iodine is converted into potassium iodide and the sodium thiosulphate into sodium tetrathionate, and knowing the amount of thiosulphate consumed, it is easy to calculate the amount of free iodine changed as explained. If a little starch solution be added to the iodine solution just before the completion of the titration, a beautiful blue coloration is produced, and this is generally done in practice, as it is so much more discernible than that of the uncombined iodine coloration. A means of stabilizing starch solution by use of salicylic acid is described by M. S. Nichols (*B.C.A.*, 1929, A, 1411).

For the determination of the amount of alkali or acid present in solutions, calculations are made based upon the amount of standardized solutions of acid or alkali required respectively, by titration, to neutralize them; this point of neutrality (the end-point of the reaction) being ascertained by means of an indicator, or substance which undergoes a marked change of colour upon the change from alkalinity to acidity, or *vice versa*. The older indicators chiefly used were turmeric, cochineal, and litmus; then, later, methyl orange and phenolphthalein. Others are aurin, gallein (alizarin violet), iodoesin ($C_{20}H_8I_4O_5$) (prepared by iodating fluoresceïn), lacmoid (resorcinol blue $[C_6H_3(OH)_2NOOH.C_6H_3]$), and methyl red.

Methyl orange, lacmoid, cochineal, and iodoesin are insensitive to weak acids; litmus is typical of the indicators somewhat sensitive to weak acids; and phenolphthalein, turmeric, and rosolic acid are highly sensitive to weak acids. Methyl orange dissolved in water is turned yellow by alkalies and pink-red by acids, and when mixed with indigo carmine is said to furnish a more sensitive indication of the end-point in many acid and alkali titrations.

Phenolphthalein dissolved in alcohol is colourless, but alkalies turn it deep pink, which is at once discharged by acids. Cresolphthalein has been recommended in place of phenolphthalein.

In the precipitation of anthranilic acid (amino-benzoic acid) from its alkaline solution by addition of mineral acid, an acid reaction to methyl red indicates the approach of the end-point; a further addition of acid indicating the point of maximum precipitation is shown by the acid reaction to thymol blue.

Thymolsulphophthalein is a useful indicator in the liming of sulphonation mixtures, a red coloration indicating that free acid is still present; when the indicator shows a yellow colour, the end-point is near, and a blue colour shows that the mixture is alkaline.

Dibromocresolsulphophthalein or dibromothymolsulphophthalein may be used as substitutes for litmus, the former changing from yellow to purple and the latter from yellow to blue.

VOLUMETRIC ANALYSES (*Continued*)—

See Berry and Durrant on "Some New Adsorption Indicators for Argentometry" (*Analyst*, 1930, **55**, 613).

With respect to the hydrogen-ion method of using indicators in volumetric analyses, it must be understood that the H-ion normal solution contains one gramme equivalent of hydrogen-ion, and this is employed as a basis for computing pH – , which is the logarithm of the reciprocal of the H-ion concentration cH or [H·] of a solution—*i.e.*, $p\text{H} - \log\frac{1}{c\text{H}}$ expressed gram-ions per litre. The pH value of neutral water is about 7, depending on temperature—*e.g.*, at 18° C. 7·07, at 22° C. 7·0, inasmuch as it contains 0·000,000,1 or 10^{-7} gram-ions of hydrogen-ions per litre. If, therefore, $C_H = 10^{-4}$, there will be present in the solution 0·000,1 gram – H·-ion per litre, the pH being 4. (See p. 465.)

Substances which change their colour as the H-ion concentration of their solutions change are used as indicators. Thus, phenolphthalein solutions, which are colourless when having $[\text{H}\cdot] = 10^{-8}$, become pink when the [H·] is 10^{-10} or less.

An automatic titration apparatus for use in water-softening control has been described by H. S. Hatfield (*Chem. and Ind.*, 1927, **46**, 1149), while the "Electrometric Titration Apparatus" is one for the estimation of acids and bases, and titrations involving oxidations or reductions. In titrations of acids and alkalies, the pH value of the solutions can be deduced from the voltameter readings at all stages, and it may be used in preparing hydrogen solutions of any desired pH value.

The colorimetric method for determining hydrogen-ion values has advantages over the electrometric method, and H. A. Ellis uses a modification of the former. Instead of comparing the colour of the sample with a series of buffer solutions, he uses in cases of great delicacy a scale of numbers, say, from 1 to 14, embracing all dilutions of acidity or alkalinity from total ionic acidity to that of alkalinity, and these are styled pH values of the indicators, and neutrality being midway between the two extremes, those with pH values less than 7 indicating acids, and those with greater values indicating alkalies, the choice of indicator resting with the particular substance best suited for the purpose.

Among other good indicators are "Sofnol" No. 1, changing red to yellow with a pH range 4·5 to 6·5; and "Sofnol" No. 2, yellow-blue to purple with a pH range 6·0 to 9·8.

Buffer action may be described as the prevention of changes in hydrogen-ion concentration of acid or alkaline solutions exercised by certain salts. (See note by E. Newbery, *Ind. Chem.*, 1927, iii., 462.)

Buffer solutions, presenting a range of colours, can be made by the addition of suitable indicators to a series of solutions, using solutions of salts such as acetates, borates, and phosphate of the alkaline metals, to which the addition of acids or alkalies causes only small changes in the hydrogen-ion concentration, and they serve as standards of comparison with others of which the pH values have to be ascertained.

Conductiometric methods of analysis "depend on the change in conductivity of a solution as addition of the used reagent proceeds."

VOLUMETRIC ANALYSES (*Continued*)—

Potentiometric methods of titration depend upon the rapid change in potential of a suitable electrode immersed in the solution to be titrated at the end-point. Other volumetric methods are based upon processes of oxidation, reduction, and precipitation.

Other References: J. F. Spencer on "An Apparatus for Potentiometric Titrations" (*J.S.C.I.*, 1927, **46,** 423 T); H. T. Britton (*Ind. Chem.*, 1927, iii., 452); T. H. Fairbrother on "Indicators" (*Ind. Chem.*, 1928, iv., 66 and 93); T. Callan and S. Horrobin (*J.S.C.I.*, 1928, **47,** 329 T); Müller and Kogert (*B.C.A.*, 1928, A, 1203; and *B.C.A.*, 1929, A, 42); B. Cavanagh (*J.C.S.*, 1928, p. 855, and 1930, p. 1425); F. J. Watson (*B.C.A.*, 1929, A, 903); J. Grant on "Indicators" (*Ind. Chem.*, 1931, vii., 197 and 227); N. Rae on "A Simple Method of Conductiometric Titration" (*J.C.S.*, 1931, p. 3143); *Volumetric Analysis,* by Francis Sutton, 11th edition (J. and A. Churchill); *Potentiometric Titrations,* by Kolthoff and Furman (Chapman and Hall, Ltd.); *The Colorimetric and Potentiometric Determinations of* p*H,* by Kolthoff and Furman (Chapman and Hall, 1931); *Indicators,* by Kolthoff and Furman (Chapman and Hall, Ltd.); Buffer Action, Hydrogen-ion Determination (p. 464), Indicators, *p*H, Reagents, and Thermionic Valve.

VRIAC—A French term for kelp. (See Barrilla, Iodine, Kelp, Sea-Weeds, and Varec.)

VULCANITE—See Rubber.

VULCANIZATION—See Rubber.

VULCANIZED FIBRE—Made by action of zinc chloride on cellulose.

WALDEN INVERSION—Stereochemical inversion—that is, the conversion of optically active substances into others of opposite rotation, such as that of *l*-chlorsuccinic acid into the *d*-isomeride, and *l*-malic acid into the *d*-malic acid by means of chemical reagents. According to H. N. K. Rørdam, two types of Walden inversion are distinguished —viz., reactions in which fusion of the active molecule is either spontaneous or otherwise caused as described by him, or those in which the inversion is the result of propinquity of radicals in an additive phase. (Compare Polarization and Racemization; see also A. M. Ward (*J.C.S.*, 1926, p. 1184, and 1927, p. 445); Hans N. K. Rørdam (*J.C.S.*, 1928, p. 2447; 1929, p. 1282 and 1930, p. 2017); and *Chem. and Ind.*, 1924, **43,** 1128.)

WALNUT OIL, expressed from the seeds of *Juglans regia* or *J. Sieboldiana,* a native of Persia and the Himalayas, and cultivated in Europe, is of pale yellowish-green colour and weak drying character, with sp. gr. 0·92 to 0·93; ref. ind. 1·4808 at 20° C.; sap. v. 192 to 197; i.v. 142 to 146; and solidifies at $-27{\cdot}5°$ C. The main constituent is linolic acid. It is soluble in alcohol and ether, and used in the varnish and paint trades and preparation of artists' colours. A recent description of a sample gives the acid value 92·3; in this instance the fruit yielded 26·54 per cent. kernel containing 4·99 per cent. water and 59·58 per cent. oil by pressing.

WALNUT OIL (*Continued*)—

A sample of Californian walnut oil more recently examined showed a content of 89·7 per cent. unsaturated and 5·3 saturated acids, the composition being given as oleic acid 17·6; linolic acid 72·8; linolenic acid 3·2; palmitic acid 4·6; stearic acid 0·9, with traces of myristic and arachidic acids, and 0·5 per cent. unsaponifiable matter (Jamieson and McKinney (*Analyst*, 1929, **54,** 241).)

Walnut extract is used in wood-staining and the paint and varnish trade, while the cake has some value as food for cattle and poultry.

WARFARE (CHEMICAL)—See Poisons.

WASH-BOTTLE—A flask fitted with a cork or rubber stopper having two borings, through which pass bent glass tubes: a short one terminating just below the stopper, while the other goes nearly to the bottom of the flask and terminates at the outside end in a drawn-out point, so that when in use (as, for instance, washing a precipitate upon a filter) the water is made to emerge therefrom in a fine stream. This is done by applying the mouth to the short tube and blowing, when the water or other liquid content is forced out of the flask through the longer tube. An improved form, provided with a simple glass valve, the use of which obviates intermittency in the flow of water and consequent splashing, is described by E. Avery Roff (*Chem. and Ind.*, 1925, **44,** 5), and another variety by H. C. Stevenson (*Ibid.*, 1925, **44,** 1112); see also the *Ind. Chem.*, 1926, ii., 375.

Wash-bottles, instead of being filled with water, can of course be charged with alcohol, ether, or other solvent, according to the solubilities of the substances to be removed from the subject-matter of the washing.

Appliances constructed on the same basis are also used for washing gases, the gas being passed or drawn through the liquid contents by the long tube, and the washed gas escaping through the shorter tube. An improved form of this type is figured in the *Ind. Chem.*, 1925, i., 109; another is described by J. Brown (*J.S.C.I.*, 1931, **50,** 306 T). (See Aspirator.)

WASHING—See A. Rayner (*C.T.J.*, 1932, **90,** 51), Gels, Soaps, Sodium (Carbonate), and Solvents.

WASTE (POWER AND PRODUCTS)—Incineration appears to be the best method of disposing of the residual matter from domestic and trade refuse after separation of any saleable contents. Reber and Scott are of opinion that "a town with a carefully operated system of refuse collection and a well-designed modern refuse destructor should be able to raise power far in excess of that required for the refuse disposal plant" (*Chem. and Ind.*, 1927, **46,** 119), and E. W. Smith (*Ibid.*, 1931, **50,** 935).

The treatment of town refuse by fermentation in closed chambers after removal of glass, rags, scrap metal, etc. (Beccari method) is described by J. Bordas (*B.C.A.*, 1929, B, 455).

The removal of sulphurous fumes from flue gases is referred to under the heading of Sulphur (Sulphuric Acid) and in some of the references

WASTE (*Continued*)—

named below, while other waste products and their utilization are dealt with under specific headings in this work.

References: J. B. C. Kershaw (*Ind. Chem.*, 1925, i., 434, 492, and 543; 1926, ii., 122, 309, 499, and 485; 1927, iii., 335; *Chem. and Ind.*, 1927, **46,** 1173 and 1197, and book (E. Benn, Ltd., London); H. F. Stevenson (*Chem. and Ind.*, 1925, **44,** 23); R. K. Newman (*Chem. and Ind.*, 1927, **46,** 877); Miss D. J. Lloyd on "Problem of Tannery Waste" (Inst. Chem. Eng., December, 1930, p. 45); "Modern Refuse Power Plant" (*Ind. Chem.*, 1928, iv., 368); "The Economical Recovery of Waste and Liquors" (*Ibid.*, 1929, v., 451); "Utilization of Trade Wastes" (*C.T.J.*, 1930, **87,** 603); "Metals from Waste Materials," by J. W. Hinchley (*C.T.J.*, 1930, **87,** 629, and Inst. Chem. Eng., December, 1930, p. 59); "Recovery of Volatile Solvents," by W. Herbert (*B.C.A.*, 1931, B, 874). (See also Effluents (Trade), Destructors, and Wood Gas.)

WATER (H_2O)—Molecular weight, 18. Water is known in the various forms of rain, snow, ice, and steam, and is a compound of hydrogen and oxygen, which in their ordinary state are both gases; but when they are made to combine—as, for example, by the agency of electricity—they form water. Some particulars respecting its formation will be found under the headings of Catalysis and Hydrogen.

The heat of formation of liquid water at 25° C., and a constant pressure of 1 atom as determined by F. D. Rossini, is $285{,}890 \pm 40$ absolute joules (*B.C.A.* 1931, A, 171).

According to Armstrong (H. E.), water is a saturated solution of hydrone (OH_2) at all temperatures (*Chem. and Ind.*, 1928, **47,** 1370), and he has expressd the view that dry steam has the molecular formula OH_2 (hydrone); that saturated steam is constituted partly of aggregates of two hydrone molecules; that aggregates of four, five, or six hydrone molecules probably exist in water; and that aggregates of six probably confer upon ice its hexagonal crystalline structure. (See also "Molecular Constitution of Water," by G. Tammann (*B.C.A.*, 1927, A, 93), and H. L. Callendar on "Critical Relations between Water and Steam" (*Nature*, January 17, 1930).

By use of the X rays, Bragg has shown that ice is a structure involving in each unit 12 hydrogen atoms and 6 oxygen atoms.

Water boils at 100° C. (212° F.), freezes at 0° C. (32° F.) to a crystalline solid having a sp. gr. of 0·93, attains its maximum density at 4° C., and, although slightly compressible, is commonly regarded as incompressible. (See footnote, p. 435.) Its vapour is decomposable at a very high temperature (at and above 500° C.), and readily so in the presence of oxidizable substances such as iron and coke. When steam is subjected to an electric discharge as in Wood's method of preparing atomic hydrogen, gas is produced of an extremely active character supposed to contain hydrogen atoms and hydroxyl molecules and capable of exerting powerful reducing and other chemical effects. (See Urey and Lavin, *B.C.A.*, 1930, A, 45.) Its importance as a catalyst

WATER (*Continued*)—

in chemical reactions is referred to under the heading of Chemical Interactions (p. 175) and is emphasized by Baker's work on the absence of reaction between dry substances (see Heat, p. 436). See also J. W. Smith's book entitled *The Effects of Moisture on Chemical and Physical Changes* (Longmans and Co., London).

In its several forms, water makes up about three-quarters of the materials constituting the surface of the earth, and enters to the extent of from 80 to 90 per cent. or more into the composition of the tissues of vegetables and animals.

It has greater solvent power than any other liquid in respect of range of substances, and its polymers enter largely into the constitution of many chemical substances, such as hydroxides, hydrates and salts, being combined in the last-named substances as so-called water of crystallization. Copper sulphate, for example, crystallizes in a form containing 5 molecules of water ($CuSO_4,5H_2O$) and magnesium sulphate with 7 molecules ($MgSO_4,7H_2O$). Sodium chloride is known in two crystalline forms—viz., $NaCl,2H_2O$ and $NaCl,10H_2O$; whilst sodium carbonate is known in chemical association with water in several forms, including $Na_2CO_3,10H_2O$, $Na_2CO_3,7H_2O$, and $Na_2CO_3H_2O$. In all such cases it must be borne in mind that the water molecules form integral parts of the compounds.

In many cases, the colours of salts are dependent upon the amount of water of crystallization, as instanced by cobalt chloride ($CoCl_2,6H_2O$), which is pink, but when gently heated to 120° C. becomes blue in colour by the loss of its water. Another compound—viz., magnesium platinocyanide—in its crystalline form contains 7 molecules of water ($MgPt CN)_4,7H_2O$) and is of a bright scarlet colour, but when heated to 50° C. it loses 2 molecules of water and becomes $MgPt(CN)_4,5H_2O$, which is of a canary-yellow colour, and upon raising the temperature to 100° C. a white salt finally results, having the composition $MgPt(CN)_4,2H_2O$. (See also Efflorescence and Deliquescence.)

Sea-water contains salts washed out of the earth's surface, including large quantities of common salt and magnesium chloride, and has a sp. gr. of about 1·025 to 1·027, as compared with ordinary water, 1·0. The water of the British Channel contains 28·05 parts NaCl, 3·66 parts of $MgCl_2$, and 4·7 parts of other mineral substances in each 1,000 parts. Potassium salts are present to the extent of about $\frac{1}{30}$ to $\frac{1}{35}$ of sodium salts, and the ratio of bromine to chlorine is about 1 to 288. An evaporating plant for obtaining salt from sea-water is described in Brit. Patent No. 256,294 (*C.T.J.*, 1926, **79**, 475).

The *Challenger* expedition determined the temperature of water at the bottom of the ocean to be +0·3 at a depth of 2,800 fathoms (5,100 m.).

Rain-water, as collected in country places where the air is not fouled with smoke and other emanations, is as nearly pure as it can be found in nature, but even then it contains about 2½ volumes of air dissolved in each 100 volumes by measure. It is a sort of distilled water; the heat of the sun evaporates water from the earth and the sea, and then,

WATER (*Continued*)—

when the air is more or less saturated with the water vapour and becomes cold enough, it is transformed and falls as rain, snow, or hail. Soft water is water which is more or less devoid of substances held in solution, so that freshly collected rain-water is quite soft in character.

When water is boiled it takes the gaseous form of steam, and when this is conducted away and cooled it becomes condensed as water once more. Several types of stills used in the preparation of distilled water are described in *Chem. and Ind.*, 1926, **45,** 296.

An electro-osmotic method of making pure water, and stated to cost less than distillation, has been described by Patin (*Chimie et Industrie,* February, 1928; *Ind. Chem.*, 1928, iv., 168) and Bartow and Jebens (*Ind. Eng Chem.,* 1930, **22,** 1020).

The "Catadyn" process of water sterilization depends upon the germicidal action of silver deposited upon porcelain or sand in a finely divided state so as to present a large reaction surface. It is stated to reduce the bacterial content by 90 per cent. in two hours, and, after removal from the apparatus and standing two more hours, complete sterilization is said to be attained.

Purified from any mineral constituents by distillation, water is in this form usually employed in laboratories for making chemical reagents and other purposes. (See Water Oven.) Steam is an effective germ destroyer, and there are a number of so-called disinfectors or destroyers by which it is generated and used for the sterilization of clothing and bedding.

Water, as ordinarily supplied for drinking purposes, containing impurities in the form of substances dissolved out of the earth with which it comes naturally into contact, furnishes supplies roughly classified as "hard" or "soft" in character. The so-called "temporary hardness" is mainly derived from the presence of calcium carbonate or chalk in solution, which is deposited as a fur or cake in tea-kettles and boilers. This deposition is due to the expulsion of carbon dioxide previously contained in the water, and which by its presence, and until expelled by the heat, holds the chalk in solution. Such waters may be softened therefore to some extent by boiling, as already explained, or by the addition of lime, which, by entering into combination with the carbon dioxide, forms insoluble calcium carbonate ($CaO + CO_2 = CaCO_3$), and this is deposited along with the carbonate previously held in solution by the carbon dioxide thus removed.

The "permanent hardness" of natural waters is largely due to the presence of the sulphates of calcium and magnesium, the degree of hardness being dependent upon the nature of the geological formation in which the water is found, and in some cases barium carbonate may be usefully employed for removing the sulphates.

Many gases are more or less soluble in water, including nitrogen, oxygen, carbon dioxide, and argon, the degree varying with the temperature and pressure.

Sand filtration of water for domestic and industrial use is greatly

WATER (*Continued*)—

employed, and combines several distinct processes, the sand itself presenting a barrier to all suspended particles of greater size than the interstices it presents, and thus forming a layer of still finer pockets in which bacteria are arrested, thus producing a slimy gelatinous film which plays an important part in the purification of the water. Storage, absence of adequate nutrient material, and dissolved oxygen are destructive agencies against *B. Coli* and some other bacteria.

Chloride of lime and chlorine are effective agents for the sterilization of water to be used for drinking supplies. The addition of 15 lbs. chloride of lime to 1,000,000 gallons of Thames water destroys the microbes from previous sewage contamination more effectually than by passage of the water through a reservoir containing 80 days' supply, while 1 to 2 parts of chlorine gas have been found sufficient to sterilize some 5,000,000 parts of water in an hour or so. Ordinarily, however, sterilization is not required in respect of supplies which have been carefully filtered and sufficiently aerated (oxidized) and stored. Minute doses of chlorine added to water completely inhibit the formation of the jelly-like deposit which otherwise acts as an effective barrier to heat transference. (See Metropolitan Water Board 18th Annual Report.)

Natural mineral and spring waters are of many diverse characters, embracing some (like Vichy spring) of alkaline character containing sodium bicarbonate; another variety of much the same class, but containing much sodium chloride in addition (such as Ems, Droitwich, etc.); alkaline salt waters containing sodium sulphate and bicarbonate (such as Carlsbad and Marienbad); various types of chalybeate waters containing iron in differing forms (such as Harrogate, Hamburg, and Saratoga); sulphuretted waters containing hydrogen sulphide (such as Harrogate, Aix, and Baden); earthy alkaline waters such as found at Bath and Pisa; thermal waters containing saline ingredients, like those occurring at Clifton and Buxton, etc.; all dependent upon geological conditions and the chemical character of their environment. (See Chambers' *Encyclopædia,* 1901, vol. vii., pp. 210-212, and *Analyst,* 1931, **56,** 745 and 776.)

Other References: Manufacture of "Flake-Ice" (*C.T.J.,* 1931, **88,** 504); Medical Hydrology and the analyses of medical waters (*Analyst,* 1929, **54,** 33); "Some Recent Advances in the Bacteriological Examination of Food and Water," by Dr. Savage (*Analyst,* 1927, **52,** 117); "Rapid Determination of Moisture," by Fairbrother and Wood (*Ind. Chem.,* 1930, vi., 442); "Oil Pollution of Seas," by C. S. Garland (*Chem. and Ind.,* 1927, **46,** 1161); "Co-ordination of Biological and Chemical Work in respect of Polluted Waters," by D. Ellis (*Ind. Chem.,* 1928, iv., 291); "Christ" Multi-stage plant for water distillation (*C.T.J.,* 1929, **84,** 523, and *Ind. Chem.,* 1930, vi., 61); Water Treatment (use of Sodium Aluminate)," by Beal and Stevens (*J.S.C.I.,* 1931, **50,** 307 T); "Theory and Practice of Aëration," by W. F. Langelier (*B.C.A.,* 1932, B, 242); Statutory enactments given in the Rivers Pollution Acts, 1876 and 1893; Report of the Joint Advisory Committee, 1928; and Water Pollution Research Board Reports, 1929-1931 (H.M. Stationery Office);

WATER (*Continued*)—

The Technology of Water, by A. A. Pollitt (E. Benn, Ltd.); *Examination of Water: Chemical and Bacteriological,* by W. P. Mason (Chapman and Hall, 1931); *Elements of Water Bacteriology,* 5th edition, by Prescott and Winslow (Chapman and Hall, Ltd.); Brine, Dulcit, Filters, Permutit, Plankton, Steam, Water Gas, and Water Softening.

WATER GAS is obtained by alternately passing air and steam over red-hot coke or powdered coal, which has the effect of decomposing the water vapour and producing a mixture of hydrogen and carbon monoxide gases the essential reactions occurring being represented as:

$$(1)\ C+H_2O=CO+H_2,$$
$$(2)\ C+2H_2O=CO_2+2H_2,$$
$$(3)\ C+CO_2=2CO.$$

The exothermic reaction which takes place during the passage of air yields carbon dioxide and some carbon monoxide, and the subsequent steam passage yields a mixture of carbon monoxide and hydrogen. A modified process employs steam and coke only. Incidentally, a variety of tar is produced in the process, from which benzol, phenol, etc., can be obtained by fractional distillation.

At 1,000° C. water gas is stated to contain about 49·5 per cent. carbon monoxide and 50 per cent. hydrogen, together with small quantities of carbon dioxide and water vapour. To make this mixture of gases (which otherwise burns without light) luminous when burning, it is mixed with oil vapours, and employed for mixing with ordinary coal gas, as also for the manufacture of hydrogen. The analysis of a water gas published by J. Hall is as follows: 46·8 per cent. hydrogen, 1·4 per cent. methane, 41·4 per cent. carbon monoxide, 0·1 per cent. oxygen, 3·1 per cent. carbon dioxide and hydrogen sulphide, and 7·2 per cent. nitrogen, having a calorific value of 296 B.Th.U. per cubic foot.

To prepare hydrogen from water gas, it is made to reduce iron oxide at about 700° to 800° C., and the metallic iron thus produced is in a subsequent stage subjected to action of steam, thus yielding hydrogen. Water gas specially prepared can be utilized for the production not only of hydrogen, but also methane, methyl alcohol, and synthol.

References: Contributions concerning "Water Gas," by M. W. Travers (*J.S.C.I.*, 1924, **43,** 355 T); A. Parker (*Ibid.*, 1927, **46,** 72 T); Gwosdz (*B.C.A.*, 1927, B, 959); A. W. Nash (*C.T.J.*, 1927, **81,** 205); T. F. E. Rhead (*B.C.A.*, 1929, B, 503); H. L. Ramsey (from powdered coal) (*Ind. Chem.*, 1929, v., 156); A. G. Grant on "Carburetting Process in Water-Gas Manufacture" (*B.C.A.*, 1930, B, 129); King and Williams on Water-Gas Process: Carbon and Thermal Balances (*B.C.A.*, 1931, B, 706); Gas (p. 387); Hydrogen (p. 460); Producer Gas, Mond Gas, and Pitch.

WATER GLASS—See Sodium (Silicate).

WATER OVEN—An apparatus for drying chemical substances (placed in suitable containers) at 100° C., consisting of a water-jacketed copper box (on a stand) which can be heated by a lamp placed below. A vent is provided for the escaping steam and for charging the jacket with

WATER OVEN (*Continued*)—

water, and through another opening on the top a thermometer fitted through a cork may be placed. Connection with a condenser for the escaping steam furnishes a supply of distilled water.

WATERPROOFING—"The basic principle in the application of a waterproofing chemical is that its presence in or on a fibrous substance modifies the surface tension between the water and the substance of the fibre" ("Omega," *C.T.J.*, 1929, **84,** 117). Rubber dissolved in various solvents is still used for the production of waterproof sheetings, the fabrics so coated being subsequently "cold cured" by passing them through a solution of sulphur chloride in carbon disulphide.

The older mechanical methods of impregnating fabrics with various filling materials such as rubber and waxes are now comparatively little used, as they do not provide for proper ventilation. The chemical processes include the ammonium cuprate method, the lanolin method, and the aluminium soap method, the last named being most frequently employed. In this process the fabric is first soaked in a strong soap solution and then passed through one of alum, aluminium sulphate, or aluminium acetate, when a compound aluminium soap is formed on the fabric. Various electrical processes have been suggested as improvements on the chemical methods, and one of these consists in saturating the fabric with a sodium soap solution, and then passing it between a graphite cathode—over which a solution of aluminium acetate flows—and an aluminium anode completely enveloped in a heavy woollen pad. Aluminium soap is thus evenly deposited on the fabric surfaces, and aluminium hydroxide is said to be forced into the interstices. Fabrics treated in this way are stated to have shown remarkable water-resisting quality, and proof against mildew. (See Soaps (Metallic).)

WATER SOFTENING—The chemical principles of water softening and some of the substances and processes used in respect thereof have been dealt with under other headings (see "Doucil," "Permutit," "Sofnol," Steam, and Water) and is the subject of an official technical paper, of which a summary is given in the *Analyst*, 1930, **55,** 46. A. R. Martin has pointed out that when certain natural materials are used for base exchange the action takes place only at the surface, whereas using synthetic materials there is an additional interior action which facilitates the water softening (see *Chem. and Ind.*, 1930, **49,** 197). Base exchange materials can be regenerated by sea-water in place of common salt, although it is not so effective. Base exchange was originally and carefully studied by J. T. Way in the years 1850-1854, and a summary of the results of his investigation is given by G. Wiegner (*J.S.C.I.*, 1931, **50,** 65 T).

The report prepared by A. R. Martin under the direction of G. T. Morgan, constituting the technical paper No. 1 (Water Pollution Research Board, H.M. Stationery Office), gives a summary of existing knowledge of this subject, and incidentally states that "the exchange of one base for another is never complete until an equilibrium depending on the concentrations of the bases in the solution is established."

WATER SOFTENING (*Continued*)—

(See A. R. Martin (*C.T.J.*, 1930, **86**, 29); Higgins and O'Callaghan on "Base-Exchange Water-Softening Materials" (*Chem. and Ind.*, 1925, **44**, 882); Hilditch and Wheaton on "Doucil" (*Ibid.*, p. 885); D. Brownlie on "Modern British Practice in Water Softening" (*Ind. Chem.*, 1925, i., 303, 352, 386, 495; and 1926, ii., 61 and 108); R. Martin on "Some Properties of Certain Base-Exchange Materials" (*J.S.C.I.*, 1930, **49**, 389 T); *C.T.J.*, 1930, **86**, 29, and 1931, **88**, 58; M. H. Hey (*Min. Mag.*, 1930, **22**, 422); Beal and Stevens (*J.S.C.I.*, 1931, **50**, 307 T); Hatfield's Hardness Recorder—see description (*Chem. and Ind.* Supplement, February 10, 1932, **51**, S 8); *Water Purification Plants*, by M. F. Stein (Chapman and Hall); *Boiler Chemistry Feed-water*, by J. H. Paul (Longmans and Co.); Report of Water Pollution Research Board for year ended June 30, 1930 (H.M. Stationery Office); Tribasic Sodium Phosphate (p. 833) and Zeolites.)

WATT—See Electricity, p. 298.

WATTLE—Bark from the Australian wattles, *Acacia pycnantha, A. mollissima,* and *A. binervata,* containing from 25 to 45 per cent. tannin, used in tanning, and of some promise as a paper-making material. Most of the supplies come from Australia and Natal, and experiments have shown that the plants can be readily grown in Ceylon. It is reported that 33,000 acres are now under cultivation in East Africa. (See Bulletin of the Imperial Institute, July, 1929, or *C.T.J.*, 1929, **85**, 3, and Tannins.)

WAVE LENGTHS—The distances between the corresponding parts of any two in series. An Angström is the unit of wave length, being the ten millionth of a millimetre (10^{-7} mm.). Waves of light from the sun or a lamp range in length from the 40,000th of an inch to half that amount. Hertzian (wireless) rays range up to some thousands of metres in length; heat, light, and ultra-violet rays vary from 0·1 to 0·4 micron. X rays range from 50 to about 0·05 millimicrons; gamma rays about 0·01 millimicron. They all travel at the same velocity as light—viz., 186,300 miles per second.

Millikan and Cameron make claim to the discovery of three definite "cosmic ray bands" of enormous penetrating powers produced by definite and continually recurring atomic transformations involving much greater energy changes than those occurring in radio-active processes, these wave lengths being shorter than gamma rays (see *J.S.C.I.*, 1928, **47**, 289 T; Twyman and Smith on *Wave-length Tables for Spectrum Analysis*, 2nd edit., 1931 (Adam Hilger and Co.); Hertzian Waves, Light, Radiation, Radio-Activity, Ultra-Violet Rays, and X Rays).

WAVELLITE—A natural aluminium phosphate ($2Al_2(PO_4)_2,Al_2(HO)_6, 9H_2O$) of crystal system, No. 4, and sp. gr. 2·3.

WAXES—Waves may be described as mixtures of esters of monohydric alcohols with fatty acids of high molecular weight. There are many waxes of mineral, animal, and vegetable origin, of which the best-known variety is **Beeswax,** produced by bees (*Apis mellifica* and other

WAXES (*Continued*)—

species) from the sugar of their food. It is somewhat yellow, tough, and solid, and can be bleached by chlorine, hydrogen dioxide, and other agents. It is extracted by centrifugal methods, is of complex composition, containing several different substances, including about 85 per cent. myricin (myricyl or melissic palmitate ($C_{46}H_{92}O_2$, or $\left.\begin{matrix}C_{16}H_{31}O\\C_{30}H_{61}\end{matrix}\right\}O$)—the melissic ester of palmitic acid—and about 12 per cent. cerotic acid ($C_{26}H_{52}O_2$ or $C_{25}H_{51}.COOH$), hexacosane ($C_{26}H_{54}$) being its parent hydrocarbon. Beeswax has a m.p. from 60·5° to 64·25° C., sp. gr. 0·96 to 0·97, ref. ind. $n^{75}_{D} = 1·4439$, sap. v. 90 to 98, i.v. 7·9 to 12·4 and acid v. about 17; it is soluble in alcohol, ether, and chloroform, and is used in making modelling composition, plasters, candles, and polishes, as also in the process-engraving and litho trades. The composition $C_{31}H_{63}OH$ has been assigned to the beeswax melissyl alcohol constituent of beeswax. (See Cerotic Acid.)

Specimens of beeswax, including various Indian supplies (*A. dorsata, A. indica*, and *A. florea*), purified from accompanying extraneous matter, are reported to have the following constants:

Indian Supplies.	Minimum.	Maximum.	Average.	Victorian Beeswax.
Specific gravity	0·9555	0·9733	0·9652	0·9478
Melting-point	60·4	66·4	61·4	64·25
Acid value	3·7	7·6	5·8	23·31
Ester value	87·4	96·0	92·1	—
Ratio ester value to acid value	12·2	26·0	16·7	—
Iodine value	4·5	7·7	5·6	12·14 (Hübl)

In general, these resemble the Chinese and Japanese varieties, but the last named appear to have a lower sp. gr. (about 0·80 to 0·81 at d^{100}_{4} (H. Ikuta).

The analysis of an Italian sample is given by D. Cortese (*B.C.A.*, 1929, B, 179), and the characters of Japanese beeswax have been recently studied by H. Ikuta (*Analyst*, 1931, **56**, 430). He shows that the differences between European and Japanese beeswaxes depend on the species of the bees rather than on the floral origin of the honey.

The yellow colour of beeswax is attributed to the *propolis* (red resinous substance) derived from exudation of the plants forming its source (see *Analyst*, 1927, **52**, 418).

Bayberry Wax (Myrtle or Myrica, Candleberry, Bayberry, Laurel Wax, Wax-berry Wax), from the bark of the *Myrica cerifera* (a native of the U.S.A.) and other species, is green in colour, and consists of palmitin, palmitic acid, myristin, and lauric acid. It melts at 40° to 44° C.; sap. v. 208·7, sp. gr. 0·97 to 0·99, ref. ind. 1·4363 at 80° C., and is used in candle-making. Certain species of *myrica* are found at the Cape of Good Hope. The bark is used in medicine.

Candelilla Wax is found as an excretion on *Euphorbia antisyphilitica* (growing in North Mexico and southern parts of the U.S.A.), from the

WAXES (*Continued*)—

leaves and stalks of which it is obtained by boiling in water and adding some sulphuric acid, the yield being about from 2 to 3 per cent. It is soluble in benzene, turpentine, and carbon tetrachloride, and used in making polishes, candles, varnishes, sealing wax, gramophone records, etc. It is yellowish-brown, opaque to translucent, and said to contain a hydrocarbon ($C_{30}H_{62}$) of m.p. 60° C. among other constituents; m.p. about 64° to 67° C., sp. gr. 0·983 to 1·00, sap. v. 46 to 65, i.v. 37, acid v. about 20, and ref. ind. 1·4555 at 71° C. (See F. le Roi Thurmond, *C.T.J.*, 1925, **76,** 10.)

Carnauba Wax is obtained as a yellowish-white or green, sticky exudation from the leaves and the berries and stalks of a palm (*Copernicia cerifera*) growing in Brazil and the southern parts of America, which are coated with it, and said to consist largely of myricyl cerotate and myricyl alcohol ($C_{30}H_{61}OH$), in which respect it resembles beeswax, for which it is used for some purposes as a substitute, also for making candles, varnishes, shoe and other polishes, phonograph records, etc. Its sp. gr. ranges from 0·990 to 1·000 at 15° C., m.p. 83° to 91° C., i.v. 13, sap. v. 78 to 88; it is soluble in hot alcohol and ether. After sun-drying it is refined by melting and bleaching with either fuller's earth, chromic acid, hydrogen dioxide, or potassium dichromate, and is marketed in a number of varieties, named "Arenosa" (sandy), "Gordurosa" (fatty), "Mediana" (medium), "Primeria" (first), and "Flor" (flower), in order of quality. It is also said to contain a large proportion of hydrocarbons, one sample giving 54·3 per cent. content. (See "Omega," *C.T.J.*, 1924, **74,** 649.)

Ceresine is a white wax-like substance obtained by purification of ozokerite with strong sulphuric acid, followed by filtration in a melted condition through animal charcoal. It is used for sizing, in candle-making, and for admixture with beeswax; sp. gr. 0·92 to 0·94, m.p. 74° to 80° C.; soluble in alcohol, benzol, etc.

Chinese Wax (Cerotin, Pela), or vegetable insect wax, is formed on the branches of a species of ash-tree (*Fraxinus chinensis*) from the secretion of the coccus insect (*Coccus ceriferus*). It resembles spermaceti; consists for the most part of a ceryl cerotate; is used in China for candle-making, and here for making leather polishes, and in sizing paper, etc. It admits, to some extent, of saponification with potash; is white to yellowish in colour, of sp. gr. 0·970, sap. v. 80 to 93, i.v. 1·4, m.p. 80° to 83° C., and is soluble in alcohol, benzol, and chloroform.

Coca Wax ($C_{33}H_{66}O_2$) is obtained from the leaves of plants of the genus *Erythroxyacæ,* including the *Erythroxylon coca* plant cultivated in Java, Ceylon, Peru, Bolivia, and Brazil, and used for chewing. After purification, it is a white amorphous substance which melts at 70° C. and is readily soluble in hot alcohol. (See Cocaine.)

Coccerin Wax—The wax of the cochineal insect. (See M. Becker, *B.C.A.*, 1931, A, 1321.)

WAXES (*Continued*)—

Cotton-Seed Wax—Contained in raw cotton to the extent of from 0·5 to 1 per cent. (See Cotton.)

Cow-Tree Wax is obtained by evaporating the latex of the cow-tree (*Palo de vaca, Brosimum galactodendron,* of the Cordilleras and Caracas), which is used as milk. It resembles beeswax in some general characters and admits of saponification.

Flax Wax is dark green or brown, hard, and takes a high polish. Its composition ranges in sp. gr. from 0·963 to 0·985, m.p. 67·3° to 69·8° C., acid v. 17·5 to 23·8, sap. v. 77·5 to 83·7, and i.v. 21·6 to 28·8. (See W. Honneyman, *Pharm. J.*, 1926, **117,** 157; and Flax.)

Ghedda (Gedda, East Indian Wax), of m.p. at 55° to 56° C., is stated to contain about 48 per cent. ceryl alcohol, 7 per cent. hydrocarbons, and about 24 to 25 per cent. hydroxymargaric acid, together with some 8 to 9 per cent. palmitic acid, etc.

Glyceria Wax forms a coating on the stems of the Australian "cane grass" (*Glyceria ramigeria*); it resembles carnauba wax; is but little soluble in ether, has a high acid value and m.p. 82° C.

Godang Wax (Getah Wax) is made from the latex of a wild fig-tree (*Ficus ceruflua* or *F. subracemosa*). The wax from *F. variegata* is reported to consist of ficoceryl alcohol and ficoceric acid or β-amyrol palmitate. It is soluble in hot alcohol.

Japan or **Vegetable Wax** (Tallow), or tree wax, is obtained in Japan, the East Indies, Indo-China, and Madagascar from berries of the *Rhus succedanea* and several species of sumach-tree by boiling the fruit in water. The kernels yield from 31 to 34 per cent. fat and the mesocarp 28·9 per cent. It is not a real wax but a glyceride, and contains palmitin with free palmitic acid. It is yellow, soluble in benzol and naphtha, of m.p. 53° C., sp. gr. 0·970 to 0·980, sap. v. 217 to 237·5, i.v. 5·9, and acid v. 10 to 25. The island of Kyushu accounts for about one-half of the total production from Japan. It is used in making soap, wax matches, candles, furniture polish, and leather-dressing. (See Sumac.)

Lignocerin Wax—See Beech-wood Tar, p. 899.

Montan Wax is extracted from the bitumen of Thuringian lignite or from *pyropissite* (obtained from the lignite of Saxony and Bohemia) by a mixture of alcohol and benzene; said to contain as its chief constituent montanic acid ($C_{28}H_{56}O_2$) of m.p. 84·4° C., and the iso-acid $C_{32}H_{64}O_2$ of m.p. 89° C. When refined by distillation with superheated steam it is white, and is used for candle-making and as a substitute for carnauba wax and ceresine; also for raising the melting-points of low-melting waxes, and in the making of gramophone and phonograph records. The refined wax melts at 95° to 96° C., has sp. gr. of 1·0, sap. v. of 82·8; is soluble in benzol, chloroform, and carbon tetrachloride. (See *C.T.J.*, 1927, **81,** 454; Wood and Nicholas (*B.C.A.*, 1928, B, 698); Holde (with others) (*B.C.A.*, 1929, B, 667, and *B.C.A.*, 1930, B, 596);

WAXES (*Continued*)—

Flaschenträger and Halle (*B.C.A.*, 1930, A, 1407); and Marcusson and Lederer (*B.C.A.*, 1931, B, 1000).)

The wax extracted from Irish peat and sold also as Montana wax is stated to be of a different character. It has a m.p. of 76° C., an acid v. of 73, sap. v. 74, and an i.v. of 16 (Ryan and Dillon).

Myrtle Wax—See Bayberry Wax.

Ocuba Wax is obtained from the fruit of *Myristica ocuba officinalis*, which grows in marshy ground on the Amazon shores, and has a sp. gr. of 0·92, and m.p. 39·4° C.; it is used in Brazil for making candles.

Ozokerite Wax—See Cerasine and Ozokerite.

Palm Wax comes from the *Ceroxylon andicola*, a palm indigenous in the tropical parts of America, on the stem of which it forms a covering. In Ecuador, trees are found in great numbers, each of which furnishes about 50 lbs. of wax. After washing with hot water, in which it does not melt, it is mixed with a little tallow and made into balls for exportation. It is yellow, and really consists of a wax and resin which can be separated by hot alcohol, the resin remaining in solution and the wax separating out as a jelly on cooling. When purified in this way it resembles beeswax in appearance and composition.

Paraffin Wax is made from ozokerite by treatment with sulphuric acid and subsequent bleaching, and is also a solid constituent of the oily distillates from natural bituminous substances (including coal, shale, lignite, peat, wood, and natural petroleum) and cracked oils, from which it is obtained by refrigeration and centrifugal force. It is a white translucent mixture of hydrocarbons of sp. gr. 0·880 to 0·915, and m.p. 60° to 65° C. Its solubility in various hydrocarbons has been determined by P. Weber and H. C. Dunlap (see *Analyst*, 1928, **53**, 397). It is soluble in turpentine, benzol, carbon disulphide, and chloroform, and comes into the market in many grades—some hard and some soft, all known as "paraffin scale" before purification—which are extensively used in the manufacture of candles, crayons, floor polishes, waxed paper, lubricants, and for waterproofing wood, corks, etc.

Some experiments reported with respect to a sample of paraffin wax, which fused between 55° and 56°, and consisted of hydrocarbons ($C = 85{\cdot}15$ per cent., $H = 14{\cdot}85$ per cent.), supposed, but not proved, to be mixtures of normal members of the paraffin series, showed that no oxidation by means of air takes place at 102° C. unless turpentine be used in association. Between 130° and 200° C. it may be more readily oxidized by air or oxygen than the liquid petroleums; water, carbon dioxide, and formic acid being evolved (partly, at any rate, from the turpentine when used). The oxidized paraffin resembles in some respects beeswax when solid, some 52·65 per cent. of saponifiable matter being obtained.

By oxidation at 150° C. in a stream of oxygen and in presence of manganese compounds it is stated to be largely resolved by catalytic action into fatty acids, the resulting mass containing 35 per cent.

WAXES (*Continued*)—

insoluble in water, and about 25 per cent. of lower fatty acids (up to C_{10}). The mixture of products is very complex, and information concerning them very indefinite.

It is reported that when paraffin wax is heated with twice its weight of Japanese clay a distillate is obtained of sp. gr. 0·7087, and i.v. 23·9, consisting mainly of paraffin hydrocarbons containing small amounts of olefines.

Pisang Wax, a powdery mass obtained from the leaves of the *Cera musæ,* indigenous in Java.

Raphia Wax is found as a whitish layer on the under sides of the leaves of a Madagascar palm. The dried leaves yield about 10 per cent.; sp. gr. 0·834, m.p. 82·5° C., sap. v. 51, and i.v. from 7·7 to 10·7.

Rose Wax—The constants of the crude wax have been given by H. Prophète as follows: m.p. 61° C., sap. v. 29·8, i.v. (Hübl) 13, Reichert-Meissl v. 1·35, acid v. 3·15. As to its composition, see *Analyst,* 1927, **52,** 102, and H. Prophète (*B.C.A.*, 1926, A, 1281).

Spermaceti (Cetaceum, Cetin), consisting of an ester (cetyl palmitate, $C_{16}H_{33}O.CO.C_{15}H_{31}$ or $C_{32}H_{64}O_2$) and its homologues, is a pearly white, fatty substance found in certain cavities of the head of the sperm whale (*Physeter macrocephalus*) and in smaller quantity in the blubber of the *Balæna rostrata.* The crude material is apt to become rancid when exposed to the air and light, and is associated with sperm oil, from which it has to be freed before it attains the scaly, brittle, yet soft character of the commercial article. It is soluble in carbon disulphide and ether; has a sp. gr. of 0·945 to 0·960, sap. v. of 123 to 135, i.v. 3·5 to 6·7, and m.p. 44° to 47·5° C. It can be distilled at 360° C. without decomposition, and repeated crystallization gives, it is said, practically pure cetyl palmitate, melting at 53° C. By hydrolysis with aqueous-alcoholic potassium hydroxide it yields cetyl alcohol ($C_{26}H_{53}OH$). It is imported from the U.S.A. and Japan, and amongst other applications is used in the manufacture of candles, soaps, and ointments. The Arctic sperm oil is also said to be a true wax, containing 43·2 per cent. unsaponifiable matter, consisting mainly (70 per cent.) of oleyl alcohol and cetyl alcohol. (See Whale Oils.)

Sugar-Cane Wax, a by-product extracted in Natal and Java in the sugar manufacture, obtained from the canes—particularly the violet species—by scraping or skimming off the juice resulting from boiling them out, or from the dried filter-press cake, using benzol as the solvent. It is hard, yellow, brown, or green, granular, soluble in hot alcohol and benzene; m.p. 55° to 62° C., sp. gr. 0·961, sap. v. from 168 to 177, and i.v. 60. It appears to contain about 45 per cent. of myricyl alcohol ($C_{30}H_{61}OH$) and another substance ($C_{30}H_{60}O_2$) associated with other constituents. It finds a ready market as a substitute for carnauba wax. (See *C.T.J.*, 1926, **78,** 606.)

Wool Wax (See Wool).

WAXES (*Continued*)—

Viscosities of Waxes—The following table is taken from an article by "Omega" in the *C.T.J.* of December 19, 1924:

Virgin beeswax	16·3
White beeswax	17·5
Carnauba wax	43·0
Japan wax	21·0
Tallow	13·0
Stearin	8·0
Spermaceti	7·4
Paraffin wax	6·7

Details of the physical constants of various flower waxes and their chemical composition are given by J. F. S. Stramin, who states that the hydrocarbons in each case seem to consist of hentri-acontane ($C_{31}H_{64}$). (See *B.C.A.*, 1927, B, 146; "Arma" on "Waxes for the Electrical Industries" (*C.T.J.*, 1931, **89**, 608), and "Waxes (Synthetic)" (*Ibid.*, p. 559).)

WEED DESTROYER—See Insecticides and Fungicides.

"WEEDEX"—A calcium chlorate weed destroying agent.

WEIGHING APPLIANCES—See Balances; paper on "Weighing in Chemical Industries," by W. A. Bentow (*Chem. and Ind.*, 1927, **46,** 741 and 764) and some Notes by F. H. Pooley (*Ibid.*, 1929, **48,** 1152).

WEIGHT—The force by which the mass of a substance is attracted by gravity, varying with the altitude where determined. The force of 980 dynes is the weight of 1 gramme. (See Force (Dyne), p. 369.)

WEIGHTS AND MEASURES (see also **Hydrometer**)—The weights and measures used by chemists are those of the decimal or metric system, and the chief factors and their English equivalents are as follows:

Capacity:

1 litre (l.) = 1,000 cubic centimetres (c.c.) = 61·02705 cubic inches = $35\frac{1}{4}$ English ounces or 1·76077 pints; and there are about $4\frac{1}{2}$ litres to the English gallon.
1 decalitre (10 litres) = 2·2 gallons.
1 hectolitre (100 litres) = 22 gallons.
1 cubic centimetre (1 c.c.) is equal to 15·43 grains (0·9996 gramme, gram, or grm.) of water at 4° C., and is the standard of the French or metric system of weights and measures.
16·386176 cubic centimetres = 1 cubic inch, and 1 cubic inch of water in air weighs at 62° F. (16·6° C.) = 252·236 grains.
1 gallon = 70,000 grains = 10 lbs. avoirdupois weight of water = 4·5366 litres, and 277·276 cubic inches = 0·160544 cubic foot.
1 cubic foot water = 62·32 lbs.

The factor for the conversion of the American gallon (3·8 litres) into the British is 0·834.

WEIGHTS AND MEASURES (*Continued*)—

Weight:

1 gramme (gram, grm., g.) (or literally 0·9996 grm.) is the weight of 1 cubic centimetre (1 c.c.) of water at 4° C.
1 milligram (mg.) is the 1,000th part of a grm.
1 mill = 1,000th part of a litre.
1 centigram (cg.) is the 100th part of a grm.
1 decigram (dg.) is the 10th part of a grm.
1,000 grammes = 1 kilogramme (kg.) = 35·2739 ozs. and 2·2046213 lbs. av.
1 English lb. = 453·59 grms., and 1 oz. = 28·35 grms.
1 grm. = 15·43235 English grains.
1 lb. = 7,000 grains.
1 gallon of water = 10 lbs., and now legalized as 4·5459631 litres.
1 cubic foot of water = 62·321 lbs.
1 cubic metre or stere = 35·3166 English cubic feet.

Length:

25 millimetres (mm.) = 1 inch.
1 metre (m.) = 39·37 English inches.
1 kilometre (km.) = 1,000 metres or 1,093·6331 English yards.
1 decimetre (dm.) = the 10th part of a metre.
1 centimetre (cm.) = the 100th part of a metre.
1 millimetre (mm.) = the 1,000th part of a metre.
1 micron = the 1,000th part of a millimetre.
A millimicron (m.) is one-millionth of a millimetre.

Avoirdupois Weights:

16 drams = 1 oz.
16 ozs. = 1 lb.
112 lbs. = 1 cwt.
20 cwts. = 1 ton.

Avoirdupois to Metric:

1 dram = 1·772 grms.
1 oz. = 28·350 grms.
1 lb. = 0·45359243 kg.
1 cwt. = 50·802352 kgs.
1 ton = 1016 kgs.

Apothecaries' Weights:

20 grains = 1 scruple (℈).
3 scruples = 1 drachm (ʒ).
8 drachms = 1 ounce (℥).
12 ounces = 1 lb.

Troy Weights:

24 grains (grs.) = 1 pennyweight (dwt.).
20 pennyweights = 1 oz.
12 ozs. = 1 lb.

British Pharmacopœia (Capacities):

1 minim = 1 drop (♏).
60 minims = 1 fluid drachm (fl. drm.) (ʒ) (1 teaspoonful).
8 fluid drachms = 1 fluid ounce (fl. oz.) (℥) (2 tablespoonfuls).
20 fluid ounces = 1 pint (O.).
8 pints = 1 gallon (C.).

Other Useful Data:

To reduce kilogrammes to lbs. multiply by 2·2046.
To reduce litres to gallons ,, ,, 0·22.
To reduce grammes to grains ,, ,, 15·432.

WEIGHTS AND MEASURES (*Continued*)—

To reduce grains to grammes multiply by 0·0648.
To reduce ounces to grammes ,, ,, 28·349.
1 inch=2·539,954 centimetres.
1 quintal=100 kgs.=1·968 cwts.
Short ton=2,000 lbs. (largely used in U.S.A.).
Long ton=2,240 lbs.
Metric ton=2,204·622 lbs.
1 stone=14 lbs.
1 stere=1 cubic metre or 35·3166 English cubic feet.
1 foot=3·047,944,9 decimetres.
1 yard=0·914,383,48 metre.
1 mile=1·609,314,9 kilometres (km.).

Square Measure:

144 sq. inches	=1 sq. foot.
9 sq. feet	=1 sq. yard.
30¼ sq. yards	=1 sq. rod, pole, or perch.
40 perches	=1 sq. rood.
4 roods	=1 sq. acre.
640 acres	=1 sq. mile.

Square Metric Measure:

Milliare =	0·1 sq. metre.
Cintiare =	1·0 ,,
Deciare =	10·0 ,,
Are =	100·0 ,,
Decare =	1,000·0 ,,
Hectare =	10,000·0 ,,

(1 sq. metre=1·196 sq. yards, and 1 sq. cm.=0·155 sq. inch.)

Cubic Measure:

1,728 cu. inches=1 cu. foot.
27 cu. feet=1 cu. yard.

Medical Prescription Signs:

½ grain ..	gr. ss.
1 ,, ..	gr. j. or gr. i.
1½ grains ..	gr. i.ss.
2 ,, ..	gr. ii.
2½ ,, ..	gr. ii.ss.
½ scruple ..	℈ ss.
1 ,, ..	℈ i. or ℈ j.
1½ scruples	℈ i.ss.

1 drachm ..	ʒi. or ʒj.
1½ drachms ..	ʒi.ss.
2 ,, ..	ʒii. or ʒij.
½ ounce ..	℥ss.
1 ,, ..	℥i. or ℥j.
½ pint ..	O.ss.
1 ,, ..	O.i. or O.j.
1 gallon ..	C.i. or C.j.

Units of Volume (National Physical Laboratory Standards, September, 1924)—The recognized international metric units are the litre (l.) and the millimetre (ml.), and they should be regarded as the standard units of volume. The ml. and the c.c. differ slightly in magnitude: 1,000 G.W.A. (gramme water in air)=1,002 ml., and 1 litre=1,000·027 c.c.

A quantity of water which weighs 1,000 grms. in air of density 0·0012 g./ml., weighed against brass weights of density 8·4 g./ml., occupies a volume of 1,002·021 ml. at 60° F.

WEIZMANN'S PROCESS—See Acetone.

WELDING: ITS CHEMICAL ASPECTS—Apart from other applications, the subject of welding is important in respect of the storage of gases, including oxygen, chlorine, ammonia, sulphur dioxide, and

WELDING (*Continued*)—

phosgene, in welded cylinders and tanks. The welded seams involve risks not experienced in solid drawn vessels. Steel used for welding in chemical and process industries should have a carbon content below 0·25 per cent. as being the most easily handled. Drums built by electric and oxy-acetylene welding of a safe and lasting character are commercially available, and by the "Murex" electric arc process girders are welded together instead of riveted.

(See Report of the Committee on Welded Containers (H.M. Stationery Office); J. R. Booer (*C.T.J.*, 1924, **74,** 189); *C.T.J.*, 1930, **86,** 53; *J.S.C.I.*, 1930, **49,** 17 T; "Welding in the Chemical Industry," by F. Leverick (*Ind. Chem.*, 1930, vi., 448); "Welding in respect of Corrosion-resisting Alloy Steels," by H. Martin (*C.T.J.*, 1931, **89,** 631); Oxy-Acetylene Flame and Thermite.)

"WELDON CHLORINE PROCESS"—See pp. 183 and 561.

WELSBACH LIGHT—See Light, p. 533.

"WESTORAN"—A proprietary emulsifiable hydrocarbon, miscible with water, for use as a solvent scourer for cotton and other fabrics, and as an insecticide.

"WESTROL"—A proprietary article described as a combination of high-class oils with a non-inflammable solvent (trichlorethylene); soluble in water; for use as a solvent scouring agent for cotton fabrics. A similar article named "Westrosol" or "Tri" is for use in respect of woollen fabrics and general washing purposes.

WETTERS (**Wetting Agents, Spreaders**) are preparations used as constituents of spraying fluids and emulsifiers to facilitate their spreading. An article named "Mercerol" is largely used in respect of cotton fibres before mercerization. The patent specification concerning "Mercerol" describes the addition of small amounts of hydrogenized aromatic substances to crude phenol (high-temperature tar). (See Sandoz, B.P. 279,784.)

According to a recent patent, salts, amides, ester-amides, or esters of high molecular organic acids used as wetting agents are improved by incorporation with wetting agents of the sulphonic acid type. Examples are β-diethylamino-ethylamide of oleic acid and sodium propylnaphthalene sulphonate; stearamide and sulphonated oleic acid; oleic β-hydroxyethylamide, or anilide, or cyclohexylamide and di*iso*propylnaphthalene sulphonic acid. (See G. Y. Johnson, *B.C.A.*, 1930, B, 705.)

Other References: A survey of existing types by Haller and Landolt (*C.T.J.*, 1930, **86,** 239, and 1930, **87,** 237); S. R. Trotman (*Ind. Chem.*, 1928, iv., 201); R. M. Woodman (*J.S.C.I.*. 1930, **49,** 93 T and 194 T); P. Woog (*B.C.A.*, 1930, B, 124); Osterhof and Bartel (*B.C.A.*, 1930, A, 1110); Harkins and Dahlstrom (*Ind. Eng. Chem.*, 1930, **22,** 897); "New Wetting Agents from Rosin" (Gubbelmann (with others), *Ind. Eng. Chem.*, 1931, **23,** 1462); Emulsions (p. 308), Introfiers, Lubrication, and Ores.

WHALE OILS—The sp. gr. ranges from 0·877 (from head cavities of sperm whale) to 0·9232 (from blubber of humpback), ref. ind. at 15·5° C., 1·463 (from head cavities of sperm whale) to 1·475 (from blubber of humpback); sap. v., 127 (from blubber of sperm whale) to 199 (tongue of humpback); acid v., 0·75 (from blubber of sei whale) to 5·8 (blubber of humpback); i.v., 0·66 (from head cavities of sperm whale) to 119 (blubber of humpback).

The oil from the humpbacked whale is reported to contain about 10 per cent. of saturated acids (chiefly palmitic and myristic), and not more than 15 per cent. of highly unsaturated acids, the remainder consisting of members of the oleic acid series. Of the simple unsaturated acids of the oleic acid series, the chief are oleic acid and one with the composition $C_{16}H_{30}O_2$, together with an isomeride of erucic acid. The oil from the finner whale has a higher iodine value; contains about 25 per cent. saturated acids, and not more than 15 per cent. highly unsaturated acids, the remainder being members of the oleic series. Zoomaric acid ($CH_3(CH_2)_5CH:CH(CH_2)_6COOH$) is said to occur in sei-whale oil. After removal of the oil the residual material can be used as a fertilizer or cattle food. The Sixty-Third Annual Report of the New Zealand Dominion Analyst gives analytical results concerning New Zealand whale oils as follows: Acid v. ranging from 5·3 to 14·8; sap. v. 190 to 191·7; i.v. 134·8 to 140·5; ref. ind. at 40° C. 1·4655 to 1·4662; ref. ind. at 60° C. 1·4575 to 1·4588, and sp. gr. at 15°/15° C. 0·923 to 0·925. These oils differ from Antarctic whale oils in throwing down hardly any stearine when chilled (*Analyst*, 1931, **56**, 182). (See also Y. Toyama (*J.S.C.I.*, 1924, Abs. B., p. 1019, and *Analyst*, 1927, **52**, 727); T. H. Barry on "The Modern Whaling Industry" (*Ind. Chem.*, 1929, v., 33); article on "Modern Whale Oil Production" (*Ibid.*, 1931, vii., 371); Fish Oils (p. 354) and Oils.)

WHATMAN EXTRACTION THIMBLES—See Filters.

WHEAT (and Bread)—Cereal grasses of the genus *Triticum*, the common wheat being *T. vulgare* or *sativum*. The flour from wheat and other cereals varies in proportions of nitrogen content, gluten (consisting of gliadin and glutenin), soluble extract (including a small proportion of oil), soluble phosphates, acidity, diastatic capacity, swelling properties of the contained hydogels, etc. The following analyses of cereals are given by S. Dixon (*Chem. and Ind.*, 1930, **49**, 667):

	Fat.	Proteins.	Carbohydrates.	% Ca.	% P.	Ca/P ratio.
Oatmeal ..	7·2	16·1	67·5	0·069	0·392	1 : 5·7
Barley ..	1·1	8·5	77·8	0·020	0·181	1 : 9·0
Rice ..	0·3	8·0	79·5	0·009	0·096	1 : 10·7
Wheat flour (white) ..	1·4	7·9	76·4	0·020	0·092	1 : 4·6
Wheat germ	7·7	21·4	51·1	0·071	1·050	1 : 14·8

WHEAT (*Continued*)—

English wheat contains from 13 to 14 per cent. water, 2·35 to 2·85 per cent. oil, 12·19 per cent. albuminoids, 68 to 69 per cent. digestible carbohydrates, 1·30 to 1·75 per cent. woody fibre, 1·7 to 1·8 per cent. mineral matter (Smetham and Dodd).

Wheat bran constitutes 13·5 per cent. of the grain and has a protein content of 15 to 17 per cent.; weight for weight it contains two to three times as much of the necessary amino-acids for nutrition as the endosperm (white flour).

Bread is baked dough charged variously with yeast for leavening or some baking powder to produce gas, in order to distend it and make it more digestible. As made from flour it is the prime foodstuff of the working classes in particular, and it has been shown that the digestibility of that made from 80 per cent. flour is practically as good as that made from 70 per cent. flour, while the difference between the digestibility of breads made from 80 and 90 per cent. flours may be represented as follows:

	80 Per Cent. Bread.	90 Per Cent. Bread.
Energy	96·14	94·5
Proteins	89·40	87·3

In other words, the digestibility is only about 2 per cent. less in the 90 per cent. flour, while there is a gain of 10 per cent. in quantity, pointing to the desirability of a higher standard of milling.

On average it contains about 37·80 per cent. water, 8·6 per cent. albuminoids, and 51·50 per cent. digestible carbohydrates.

Some particulars respecting plantain (banana) flour are given by E. A. Ullán (*Analyst*, 1926, **51**, 634).

Ethyl acetate is a safe and effective fumigant for wheat at shipping terminals, where it is inadvisable to use carbon disulphide. Ethylene oxide is also said to be an efficient agent, but, according to Roark and Cotton, ethylene dichloride with carbon tetrachloride in ratio 3 : 1 by volume at rate of 6 lbs. per 1,000 cubic feet of stored grain appears to be the best fumigant (*B.C.A.*, 1930, B, 634).

The bleaching of flour by chemical reagents such as chlorine, nitrous acid, nitric peroxide, nitrogen trichloride, benzoyl peroxide, and persulphates is attributed to the formation of colourless derivates of carotene (the yellow colouring matter of the endosperm), and is stated to be attended with some loss of its vitamin A content, but not destructive of the B variety. (See Javillier, *B.C.A.*, 1926, B, 211.) In any case their use, as also that of mixings and colourings, is undesirable. (See Report of the Departmental Committee on the Treatment of Flour with Chemical Substances (H.M. Stationery Office), referred to in the *Analyst*, 1927, **52**, 226.) When chlorine is used alone or with ½ per cent. nitrosyl chloride, from ½ oz. to 2 ozs. per sack of 280 lbs. flour is employed, but the most modern practice is the employment of from 2 to 5 grams of nitrogen trichloride per sack of flour.

References: "Studies in Cereal Chemistry," by T. H. Fairbrother (*Ind. Chem.*, 1929, v., 91, 153, 199, 243, 281, 313, 373, and 408);

WHEAT (*Continued*)—

"The Science of Flour Milling" (*Ind. Chem.*, 1929, v., 413); Blish and Sandstedt on "Nature and Identity of Wheat Glutenin" (*J. Biol. Chem.*, 1929, **85,** 195); "A Study of the Function of Emulsions of Oil and Water in Bread-making, with Special Reference to Gluten Formation and Modification," by J. C. Van Dyk (*J.S.C.I.*, 1930, **49,** 421 T); "Physical Chemistry of Starch and of Bread Baking," by J. R. Katz (*B.C.A.*, 1930, B, 1043); "Bacteriology of Wheat and Flour," by D. W. Kent-Jones and A. J. Amos (*Analyst*, 1930, **55,** 248); "Chemical Changes in Wheat induced by Elevated Temperatures" (W. F. Geddes, *B.C.A.*, 1930, B, 583); D. Ellis on "Fermentation in the Baking Industries" (*Ind. Chem.*, 1926, ii., 249 and 322); "Some Factors Influencing the Strength of Wheat and Flour," by J. S. Remington (*Ibid.*, ii., 35); "The Conditioning of Wheat" (*Ibid.*, ii., 203); "Washing of Glutens from Flour," by Kent-Jones and Herd (*Analyst*, 1927, **52,** 439); and Amos and Kent-Jones on "Ropiness" (*Analyst*, 1931, **56,** 572); *Modern Cereal Chemistry*, by D. W. Kent-Jones (Northern Publicity Co., Ltd.); *Chemistry of Wheat Flour*, by C. H. Bailey (Catalog. Co., Inc., N.Y.); *Chemistry of Bread-making*, by J. Grant (E. Arnold and Co., London); and *Bread-making: its Principles and Practice*, by E. B. Benion (Oxford University Press, London); see also Yeasts.

WHEY—See Lactose and Milk.

WHISKY—Spirit distilled from fermented wort prepared from malted barley dried over a peat fire; in other words, a spirit distilled from a mash of cereal grains saccharified by the diastase of malt, and subsequently fermented by the agency of yeast.

WHITE ARSENIC—Arsenious oxide. (See Arsenic Compounds, p. 60.)

WHITE DAMP—See Carbon (Oxides).

"WHITE GOLD"—An alloy of gold and platinum which resists nitric acid and is much used in the jewellery trade.

WHITE LEAD—Since the description of the various processes of manufacture described under Lead Compounds (p. 525) was sent to press a new patented method has been described by J. F. Sacher, of Dusseldorf, by which a basic lead carbonate is produced. Finely divided litharge is made into a stiff paste with water or dilute solution of ammonia, and a mixture of ammonia and carbon dioxide gases is passed through at the ordinary or raised pressure. The ammonia is stated to act only as a carrier for the carbon dioxide and water to the lead oxide. (See Paints and Turpentine.)

WHITE METALS—Bearing or anti-friction metals, being alloys of tin, antimony, and lead or copper; another variety for pivot bearings is made of 88 parts lead and 12 parts antimony. (See *Metallurgy of White Metal Scrap and Residues*, by E. R. Thews (Chapman and Hall, London); and Alloys.)

WHITE VITRIOL—A commercial name for zinc sulphate.

WHITEWASH—Slaked quicklime made into a milk with water.

WHITING—A finely pulverized preparation of chalk purified by washing; used in making polishing and scouring materials, distemper paints, putty, aerated waters, and in the rubber and oilcloth industry. (See *Ind. Chem.*, 1926, ii., 489, and *C.T.J.*, 1931, **88**, 234.)

WIJ'S NUMBER—See Fats (p. 337).

"**WILKINITE**"—A Wyoming deposit of similar character to "Bentonite." (See Bentonite.)

"**WILLESDEN PAPER**"—See Cellulose (p. 160) and Copper (p. 239).

"**WILTON PIPE STILL**"—See Distillation.

WINE—The fermented juice of grapes (of which there are some 600 varieties), the colour depending upon that of their husks if and when they are included in the making. Red grapes can be made to give yellow or white wines if the husks be excluded, as in the cases of sherry and champagne. Portugal is famous for port; Spain for sherry; Germany for hock and moselle; Italy for capri and chianti; France for claret, burgundy, chablis, sauterne, and champagne; Greece and Spain for malmsey; while good wines are also produced in Australia, South Africa, California, etc.

The flavour and other characters of wines depend not only upon the kind of grapes from which they are made, but also upon the soil on which they are grown and upon the ethereal bodies resulting from changes that take place upon keeping. Dry wines contain little or no grape sugar; sweet wines contain sugar in greater or less proportion; while effervescent wines like sparkling moselle and champagne contain sugar in a state of fermentation, or are effervescent as the result of fermentation that takes place after bottling. They all contain alcohol as a natural product of the fermentation by which they are produced (the ferments consisting of the living organisms contained in the so-called "bloom" of the husks), together with, in many cases, small quantities of sugar, acids (including tartaric acid), colouring matters, and so-called extractive matters of indefinite composition. Old wines, particularly port, deposit acid-potassium-tartrate upon long keeping. (See Tartar.)

Alcohol is added to many wines, such as port and sherry, and some of the Australian and Californian wines, in order to "fortify" them, as it is termed, against the acetic change that might otherwise subsequently take place of the smaller natural content of alcohol. The alcoholic strength of wines is by no means constant, but as sold it may be said that port contains from 14 to 23 per cent.; sherry from 14 to 18 per cent.; claret from 6 to 12 per cent.; rudesheimer and other light wines from 5 up to 8 per cent.; beer, 5 to 6 per cent.; small beer, 2 per cent. (See Beer and Yeasts.)

WINE (*Continued*)—

It is said that to produce good wines, the grape juice must contain not less than 20 per cent. glucose, but not infrequently sugar is added to the "must" (expressed juice of the grapes).

See *Origin, Nature, and Varieties of Wine,* by Thudichum and Dupré (Macmillan and Co.); *The Chemistry of Wine-making,* by J. T. Hewitt (H.M. Stationery Office, 1928); and *Report on the Composition of Some of the Commoner British Wines and Cordials* (H.M. Stationery Office).

WINTERGREEN (OIL OF)—See Gaultheria Oil and Methyl Salicylate.

WIRE and its Manufacture—See *Chem. and Ind.,* 1930, **49,** 74.

WIRELESS TELEPHONY—See Hertzian Waves and Wave Lengths.

WITHERITE—Mineral barium carbonate ($BaSO_4$), of crystal system, No. 4, and sp. gr. 4·3.

WOAD—Blue colouring matter prepared from the leaves of *Isătis tinctoria* (Dyer's Woad, *L. tinctoria*), which contains indican and is chemically identical with indigo. The leaves after partial drying are pounded into a paste and allowed to ferment preparatory to extraction of the colouring matter thus produced.

WOLFRAM—See Tungsten.

WOLFRAMITE—See Tungsten.

WOLLASTONITE—A natural calcium silicate ($CaSiO_3$), of crystal system, No. 5, and sp. gr. 2·7 to 2·9.

WOOD—Wood consists of a mass of cells possessed of walls and containing a great variety of substances, such as ligno-cellulose (the fundamental constituent), starch, resinous matters, essential oils, etc. (See J. M. Maby on its structure (*Analyst,* 1932, **57,** 2).) By some, it is thought probable that lignin and carbohydrates are contained in the wood as glucoside-like compounds, and that in the sulphite-boiling process (see Paper, p. 669) these are hydrolysed, soluble calcium-lignin sulphates being thereby produced.

The greatest forest reserves of hard and soft woods are those of Siberia, the Russian far east, and the N. American territories.

In England a seedling tree doubles its size in two years, and at twenty years a good growing larch will increase as much as 20 per cent. in the following year, while at forty years the percentage growth will still be about 6 per cent. per annum.

Timber imports into this country from abroad have been estimated for 1928-9 as about £45,000,000 value.

P. Klason has devised a reagent which at 100° is capable of removing the lignin from wood, leaving a residue which may serve as a technical definition of the "cellulose" component. (See *Papier-Fabr.,* February, 1924, **22,** 373-377; or *J.S.C.I.,* 1924, **43,** B, 89.)

The following table of analyses is taken from a published paper by G. R. Ritter and L. C. Fleck:

WOOD (*Continued*)—

ANALYSES OF CERTAIN AMERICAN HARD AND SOFT WOODS ON MATERIAL DRIED AT 105° C.

	Western Yellow Pine.	Yellow Cedar.	Incense Cedar.	Red-wood.	Tanbark Oak.	Mes-quite.	Balsa.	Hickory.
Ash	0·46	0·43	0·34	0·21	0·63	0·54	2·12	0·69
Soluble in cold water ..	4·09	2·47	3·64	7·36	4·10	12·62	1·77	4·78
Soluble in hot water ..	5·05	3·11	5·38	9·86	5·60	15·09	2·79	5·57
Soluble in ether	8·52	2·55	4·31	1·07	0·80	2·30	1·23	0·63
Soluble in 1 per cent. NaHO solution	20·30	13·41	17·69	20·00	23·96	28·52	20·37	19·04
Acetic Acid	1·09	1·59	0·91	1·08	5·23	2·03	5·80	2·51
Methoxy content	4·49	5·25	6·24	5·21	5·74	5·55	5·68	5·63
Pentosan	7·35	7·87	10·65	7·80	19·59	13·96	17·65	18·82
Methyl-pentosan	1·62	3·42	1·35	2·75	None	0·70	0·86	0·80
Cellulose	57·41	53·86	41·60	48·45	58·03	45·48	54·15	56·22
Lignin	26·65	31·32	37·69	34·21	23·85	30·47	26·50	23·44

An analysis of spruce wood gives the cellulose content (free from pentosans) to be 53 per cent., that of hemi-cellulose as 15 per cent., lignin 30 per cent., and other substances 2 per cent.; while E. Hägglund gives the constituents of pine wood as cellulose about 42 per cent., polysaccharides 24 per cent., lignin 28 per cent., acetic acid 2 per cent., and rosin, ash, and protein, etc., about 4 per cent. (See *B.C.A.*, 1929, B, 201.)

The results of a published analysis of oak wood (*Quercus agrifolia*) are as follows:

	Per Cent.
Loss on drying	4·20
Benzene extract	0·50
Alcohol ,, ...	4·33
Water ,, ...	3·66
Soluble in cold 5 per cent. sodium hydroxide solution	18·71
Cellulose	45·48
Lignin	20·25
Pentosans not otherwise accounted for	1·89
Mannan (residual)	None
Galactan ,, ...	1·49
	100·51

The wood of a deciduous tree (aspen) gave upon a recorded analysis: ash, 1·03 per cent.; fats and resins, 1·07 per cent.; methoxyl (OCH_3), 6·02 per cent.; pentosan, 17·61 per cent.; lignin, 26·42 per cent.; cellulose, 51·61 per cent.; galactan, 0·99 per cent. (Heuser and Brötz, *B.C.A.*, 1925, B, 585.)

Green wood contains from 40 to 60 per cent. water, and ordinary dried woods contain about 50 per cent. carbon, 6 per cent. hydrogen, 40 to 42·5 per cent. oxygen, 1 per cent. nitrogen, and yield from 0·81 to 3·37 per cent. ash.

WOOD (*Continued*)—

Wood can be completely dissolved by heating at 75° in acetic anhydride and zinc chloride, coupled with passage of chlorine through the mixture, and from examination of the product resulting from pouring into water, H. Urban has found that the composition of wood agrees with the assumption that it consists in the main of 70 per cent. cellulose and 30 per cent. lignin. (*B.C.A.*, 1926, B, 531.)

The wood from various species of trees varies in structure, specific gravity, elasticity, and strength. The following table gives the average sp. gr. of various woods:

Cork	0·240
Poplar	0·384
White pine	0·39 to 0·456
Yellow pine	0·448
Larch	0·51 to 0·53
Mahogany (Honduras)	0·560
Cedar (United States)	0·561
Willow	0·585
Chestnut	0·610
Birch (United States)	0·648
Sycamore	0·624
Teak	0·660 to 0·750
Walnut	0·671
Oak (United States)	0·672
Elm	0·673
Pine (red)	0·673
Mahogany (Spanish)	0·720
Pine (pitch)	0·736
Maple	0·752
Hornbeam	0·761
Yew	0·788 to 0·808
Birch	0·793
Ash	0·845
Beech	0·852
Red gum (eucalyptus)	0·901
Logwood	0·913
Cedar (Canadian)	0·910
Oak (English)	0·934
Oak (African)	0·944
Blue gum (eucalyptus)	1·100
Ebony	1·208 to 1·331
Box	1·328

The next table, giving the coefficients of absorption, is taken from an article by D. M. Newitt in the *Chemical Age* of August 26, 1922:

COEFFICIENTS OF ABSORPTION (GRAMMES PER CUBIC CENTIMETRE × 10).

Liquid.	Cypress.	Fir.	Pine.	Redwood.	Maple.	Oak.
Water	2·34	3·1	3·0	3·6	5·4	4·0
Hydrochloric acid	2·3	2·6	2·4	2·8	4·2	3·6
Sulphuric acid	2·2	2·0	3·1	3·1	4·1	2·6
Nitric acid	2·2	2·7	2·3	2·8	4·8	3·8
Caustic soda	4·0	5·7	4·3	6·0	5·7	7·0
Sodium carbonate	2·0	3·6	2·5	4·2	4·2	2·4
Bleaching powder	1·5	2·0	1·3	3·1	3·9	1·6
Sodium bisulphite	3·6	3·3	1·8	4·4	4·4	2·5
Sodium chloride	1·0	1·6	1·2	3·1	3·5	1·3
Turpentine	2·5	1·6	0·7	3·1	1·9	0·7
Linseed oil	1·2	2·0	1·0	3·0	1·6	1·0

WOOD (*Continued*)—

To quote his words, "For any particular liquid there is always some wood which is particularly resistant to that liquid, and which should be selected for building the tank. Caustic soda and nitric acid are exceptions to this generalization; they cannot satisfactorily be stored in wood. The same applies to most hot alkaline and acid liquids."

A feeding stuff for cattle and pigs midway in composition between starch and glucose is being made in Germany by the partial hydrolysis of wood waste. (See Alcohols (Ethyl), p. 22.)

"The Effect of Acids on the Mechanical Strength of Timber" is the subject of an article by E. A. Alliott (*J.S.C.I.*, 1926, **45**, 463 T).

As to the identification of wood by chemical means, see *Analyst*, 1932, **57**, 101.

Decay—All woods are more or less liable to the attacks of fungi and the decomposition known as dry rot; heat, air, and moisture being necessary for the growth of all dry-rot fungi, which, however, will not thrive in the presence of a great excess of either of these agencies. In this change, the proportions of carbon and hydrogen contained in the wood are reduced by the production of carbon dioxide and water. It is largely one of slow oxidation, accompanied by a loss of density, until the wood, as in the case of trunks of trees hollowed by decay, becomes rotten. Soft woods are more frequently attacked than heartwood, and quick-growing timber more so than that of slow growth.

The fungi *Polyporus hybridus* and *Melaphora puteana* are, according to one account, held responsible in the main, but more than seventy different kinds have been isolated from wood and wood pulp, and the ravages of many forms of insect life are involved in the general destruction. Coniferous timber, affected by the blue-stripe fungus *Ceratosomella*, is not infrequently used for building, under the wrong impression that the appearance is due to sap-wood.

The fungi responsible for the decay of wood may be said to consist of two classes—viz., the dry-rot type, which flourishes within a narrow range of temperature (cold to moderate) and does not require any great amount of moisture; and the damp-rot type, which thrives in warmer temperatures and requires much moisture. Among the common wood-destroying fungi are *Lenzites trabia, L. lepideus, Fornes roseus, L. sæpiaria, Merulius lacrymans,* and *Coniphora cerebella,* the last-named being the organisms which cause dry-rot more frequently in worked timber out of doors than inside buildings. In spruce, hemlock, balsam, and aspen, the progress of decay is indicated by a decrease in the content of stable cellulose and increase in that of lignin; ultimately, at least 50 per cent of the lignin is converted into humic acid.

According to Barton-Wright and Boswell, the *Merculius lachrymans* removes the galactin, mannan, and cellulose fractions from spruce, while the hemi-celluloses and lignin are not affected—*i.e.*, there is no delignification of the woody tissue (*Analyst*, 1929, **54**, 358).

Furniture and the woodwork of houses are also liable to attack by the larvæ of certain beetles, of which some five species occur in this country, the common furniture beetle being the *Anobium punctatum* De J., while

WOOD (*Continued*)—

the Death-watch beetle, *Xestobium rufovillosum* De J., more usually affects the timber (particularly oak) of old houses, and the powder-pest beetle (Lyctus) mostly affects sap-wood (new furniture and sawn timber). Heat-treatment is the best remedy when applicable; otherwise, fumigation with a fungicidal vapour such as formaldehyde, or, better still, the application by spray or otherwise of properly diluted solutions of powerful agents such as "okol," creosote, carbon tetrachloride, dichlorbenzene, chlorinated naphthalenes, and copper sulphate to the surfaces, joints, and cracks.

A reference to the Death-watch beetle is made in *Chem. and Ind.*, 1931, **50,** 329, and C. E. Bebbington states that he has invented a mixture which kills this pest with one dressing by spray which fills up the holes and the poison acts so that there is no need to renew the application; but the nature of the mixture is not disclosed.

With respect to moisture-proofing of wood, aluminium leaf-proofing has been advocated as providing the best protection as compared with oils, varnishes, asphalt, paints, etc.

(See M. E. Dunlap (*C.T.J.*, 1927, **80,** 118); R. Falck and W. Haag (*B.C.A.*, 1927, B, 213); Bulletin on Dry Rot in Wood, by the Forest Products Research Board, issued in 1928 (H.M. Stationery Office) (see *C.T.J.*, 1928, **83,** 119); leaflet giving an account of the Death-watch beetle, to be obtained on application to the Director, Forest Products Research Laboratory, Princes Risborough, Bucks; *Enemies of Timber,* by E. G. Blake (Chapman and Hall, Ltd., London); and other references given on pp. 995-997.)

Distillation—The distillation or carbonization of wood is conducted in cast-iron retorts, and is now a large industry, yielding four primary products (in addition to the gases which are generated)—namely, charcoal (left behind in the retorts), which can be used in making briquettes or otherwise utilized; acetic acid (recovered as acetate of calcium from the pyroligneous acid contained in the "green-liquor" or watery distillate), methyl alcohol, and tar. This tar is more complicated in character than coal tar, seventeen phenolic constituents having been identified, also numerous acids, aldehydes, ketones, lactones, aliphatic and aromatic hydrocarbons. Some details regarding pine-wood tar will be found on pp. 899-900, under the heading of Tar. Wood creosote is obtained from the distillation of the tar. (See Creosote (Wood).) The gases consist of about 15 per cent. hydrogen, 11 per cent. methane, 26 per cent. carbon dioxide, 41 per cent. carbon monoxide, and 7 per cent. hydrocarbons, and can be utilized for heating the boilers and the retorts.

Wood rich in resin, such as that from pine-trees, yields also turpentine, and by pushing the distillation further, the resin contained in the wood yields:

Rosin spirit distilling between	80°	and	150° C.
Rosin pine oil ,, ,,	175°	,,	250° C.
Blue rosin oil ,, ,,	250°	,,	400° C.

WOOD (*Continued*)—

The wood-distillation products of Canada in 1918 were reported to be as follows:

Wood alcohol (crude, and sold as such)	875,024	gals.
,, ,, (refined, ,, ,,)	1,070,928	,,
Acetate of lime	25,998,139	lbs.
Acetic acid	1,772,223	,,
Acetate of sodium	295,572	,,
Acetone	3,458,810	,,
Formaldehyde	1,154,902	,,
Ketone oils	792,864	,,
Acetic anhydride	44,981	,,
Methyl acetate	132,121	,,
Charcoal	6,472,925	bush.

and other miscellaneous products of a total collective value of $7,235,217. Hard woods are almost exclusively used in the Canadian industry, as they yield higher percentages of acetic acid and methyl alcohol than the soft varieties. The largest distillation plant in Europe is at Teslic, in Bosnia, said to be capable of distilling 200,000 space metres, equivalent to 130,000 tons per annum.

Ozonized air has been applied for the seasoning of wood, and this ("Otto" process) is claimed to effect within a few weeks the same results that the natural process takes, in many cases, several years to effect. The wood is gently heated in a current of the ozonized air, whereby water is evaporated and oxidation of the organic components of the cell sap is effected, thus obviating the emptying of the cells as in other drying processes, and the defects arising therefrom—viz., lifelessness and brittleness. On the other hand, it has been alleged that these so-called "organic sap constituents" are mythical, and that "the proper seasoning of wood is obtained by simply drying it with the least possible injury due to too rapid or irregular drying." (See Drying.)

According to Campbell and Booth, air and kiln drying of wood decreases the total pentosans, but increases the cellulose-pentosans, and the lignin soft woods can be kiln-dried more easily than hard woods because of their lower pentosan content (*B.C.A.*, 1930, A, 967). An apparatus has been recently devised for automatically controlling the kiln, the action being dependent upon the change of weight of one of the boards of the stack being dried.

Wood of any kind can be softened by saturation with an aqueous solution of any kind of soap, and there is a patented process for producing in this way from fir, spruce, and alder a substitute for Florida cedar wood for making pencils.

Wood flour finds a number of industrial applications, being used in the making of linoleums, of dynamite (as an absorbent for the nitroglycerine), as a filler in plastic products, the making of Sorel cement, and as an application in the way of flecks on certain wallpapers, etc.

Wood is used and wood waste is utilized to some extent for the production of gas, glucose, alcohol, and otherwise (see *Ind. Chem.*, 1927,

WOOD (*Continued*)—
iii., 539, and 1932, viii., 114 (Sawtelle process); W. T. Schreiber (*C.T.J.*, 1930, **86,** 526); and Auden and Joshua on the "Saccharification of Wood" (*J.S.C.I.*, 1932, **51,** 11 T).) According to M. Naphtali (*B.C.A.*, 1930, B, 388), dried wood waste gives a yield of 60 to 70 per cent. of its carbohydrate content in sugar and a yield of 30 per cent. of its weight in lignin when treated on the counter-current principle with concentrated hydrochloric acid; while a process has been devised for the preparation of carbohydrate feeding stuffs from it.

Other References: The modern hard-wood distillation process, by F. G. Conyers (*Chem. and Ind.*, 1929, **48,** 88); "A Modernized Wood-Distillation Plant," by J. Schwyzer (*B.C.A.*, 1930, B, 401); M. Schofield (*Ind. Chem.*, 1929, v., 141, and *C.T.J.*, 1930, **87,** 555); Dadswell and Hawley on "Chemical Composition of Wood in Relation to Physical Characteristics" (*B.C.A.*, 1929, B, 1044); M. Schofield on "The Distillation of Wood Waste and the Utilization of the Products" (*Chem. and Ind.*, 1930, **49,** 1057); M. Schofield on "Hard Wood Distillation and Wood Chemicals" (*Ind. Chem.*, 1931, vii., 505); Postovski and Peretz on "Wood Tar" (*B.C.A.*, 1929, B, 704); H. Pringsheim and A. Schreiber (*B.C.A.*, 1927, B, 720); Dumesny and Noyer on *Wood Products* (Ernest Benn, Ltd.); H. M. Bunbury on *The Destructive Distillation of Wood* (E. Benn, Ltd.); M. Klar on *The Technology of Wood Distillation,* translated by A. Rule (Chapman and Hall, Ltd.); *British Hardwoods: their Structure and Identification,* by L. Chalk and B. J. Rendle (H.M. Stationery Office); and R. W. Sindall and W. Bacon on *Wood and Cellulose* (Baillière, Tindall and Cox); Alcohols (Methyl), Cellulose, Glucose, and Paper.

Preservatives—For the protection of wood from moisture, asphalt and pitch paints are efficient, while aluminium leaf can be used for large, unbroken surfaces such as aeroplane propellers; various lacquers, varnishes, and vaseline smeared over varnish, are also available for certain applications. Creosote is more largely used as a general wood and fence preservative than any other agent. The quality of b.p. 210° to 355° C., with a sp. gr. of 1·09 at 20° C., is ordinarily regarded as good for railway sleepers, used at 178° F., employing from 15·6 to 18·7 lbs. per cubic foot of timber under reduced pressure, the wood being first dried by stacking. Coal-tar oils containing some carbolic acid are said to be even better, but inferior to "Basilite"—a mixture of 88·9 per cent. sodium fluoride and 11·1 per cent. dinitrophenol-aniline, which, in quantities of 3 kg. per cubic metre of wood, is said to have superior properties to all other preservatives and to be comparatively economical.

Zinc chloride (used with or without creosote) and petroleum oils are also used in respect of railway sleepers.

The impregnation of dried wood with cold solution of mercuric chloride is alleged to give permanent preservation with 2 or 3 per cent. of the salt, although it is only absorbed and does not enter into combination with the wood substance, but it is expensive and its poisonous character makes its use very dangerous. (See Kyanizing.)

WOOD (*Continued*)—

Impregnation with sulphur can at times be usefully employed for wood preservation, and experimental trials of a medium petroleum distillate containing a small proportion of an organic arsenical compound have proved resistant to the attacks of *teredo* and *limnoria* over a period of four years (Thiviver (with others), *J.S.C.I.*, 1925, B, 208, 761, and 762).

Sulphate of copper used in solution of 1 or 2 per cent. strength is useful, but it affects iron nails and spikes, and is apt to be washed out by water when exposed to its influence. Ferrous sulphate can also be usefully employed for certain applications, in particular wooden garden fences.

A preservative named "Ac-zol" is claimed to have all the advantages without the objections of some of the older preservatives, and is made up of ammonia salts, copper and zinc salts, and phenols. It is said to be readily absorbed, exhibits good antiseptic and insecticidal properties, and should be used in the proportion of 6 or 8 parts with 94 or 92 parts of water, applied by immersion, vacuum-pressure treatment, or by the brush. It contains 150 times the percentage of phenols and 10 times the percentage of metallic salts required to sterilize gelatine (which substance is more liable to fungoid attack than ligneous matter), and the compound is claimed to fix the phenols constituting the active constituents of creosote.

Many preparations have been tested for protection against the Lyctus beetle and the Death-watch beetle in timbers, one such being a watery emulsion of zinc or barium oleate 3, cedar-wood oil 3, soap 1, paraffin wax 10, and water 83 parts. Where colour is not material, copper oleate may be used and a volatile poisonous insecticide such as dichlorbenzene added. "Okol" properly diluted is also effective.

To strengthen decayed timber and at the same time to carry a permanent poison and evolve a penetrating vapour, cellulose acetate, fluosilicates, hard waxes, and silicon esters are among the materials that have been more or less used.

A solution of 1 per cent. sodium fluoride and 0·66 per cent. mercuric chloride is of value for the prevention of mould formations in wood.

For the protection of mine timber against fungi, a 5 per cent. solution of zinc sulphate under pressure is sometimes used; whilst old oak may be protected against the attacks of worms and beetles by impregnation with a mixture of two parts linseed oil and one part turpentine oil.

In the "Cobra" method of wood preservation the preservative liquid, consisting of an aqueous solution of sodium fluoride, sodium dinitrophenoxide, and some zinc chloride, is injected through bore-holes several centimetres deep.

A novel method is that of impregnation of the wood with synthetic resins in liquid form, which is said to fill all the interstices and cells, and causes coagulation of the albuminous content, thus rendering it impervious to bacteria, fungi, etc.

See B. J. Brajnikoff (*Ind. Chem.*, 1930, vi., 502, and 1931, vii., 32, 53, 115, 157); "Progress in Wood Preservation" (*Ibid.*, 1931, vii.,

WOOD (*Continued*)—

293); an article on the structure of timber, its preparation for use, preservation, various applications, some economics of the trade, and re-afforestation, by E. A. Rudge (*Chem. and Ind.*, 1930, **49,** 697); (*.T.J.*, 1930, **86,** 8 and 35; J. W. Munro (*C.T.J.*, 1931, **88,** 122); *A Treatise on Wood Preservation,* edited by F. Mahlke (Julius Springer, Berlin); *A Century of Wood Preserving,* edited by H. Boulton (P. Allen and Co., London); Reports of the Forest Products Research Board (H.M. Stationery Office); references given on p. 993; and "Thanalith."

WOOD FIREPROOFING—See Fireproofing.

WOOD FLOUR—As prepared from sawdust or pounded wood by special types of mills or grinding machines, this material is largely used as a "filling" in linoleum making; as a constituent of dynamite (being highly combustible and an excellent absorbent of nitroglycerine); also in the making of "bakelite"; as a surfacing material in the making of velvet wall-papers, and as a non-breakable material in making of dolls, various toys, and other articles.

WOOD GAS—See Sawtell Process (*Ind. Chem.*, 1932, viii., 114).

WOOD OIL—See Tung Oil.

WOOD PULP is prepared for use in the manufacture of paper and artificial silk by a number of processes—"mechanical," "semi-chemical," "sulphite," "sulphate," "soda," and so-called "kraft"—all being directed to obtain the constituent cellulose dissociated more or less from its accompanying substances, the lignin being chemically combined with carbohydrates. It is susceptible of attack by some seventy organisms, against which measures of protection have to be observed. In 1925 Canada produced 2,772,507 tons of wood pulp and 1,884,705 tons of paper. (See Paper, and Wood (Preservatives), p. 995.)

WOOD SPIRIT—See Wood (Distillation), Alcohols (Methyl), and "Synthol."

WOOD SUGAR—See Glucose, Sugar, and Wood.

WOOD TURPENTINE—See Pine Oil and Turpentine.

WOOD'S FUSIBLE METAL—M.p. 60·5 C. (See Alloys and Bismuth.)

WOOL—The cleansed fibres from sheep and goat skins, of which the outstanding chemical constituent is cystine. It is of a protein character and is related to horn, containing from 49 to 52 per cent. carbon, 6·8 to 7·2 per cent. hydrogen, 20 to 21 per cent. oxygen, 18 to 19 per cent. nitrogen, and about 3·22 to 3·4 per cent. sulphur. Wool contains fat (up to about 2 per cent.) and some cholesterol, also both aliphatic and aromatic amino groups (the total amino-nitrogen being probably about 0·7 per cent.), and is decomposed by hot caustic alkaline solutions.

The fat or grease found in wool, known as "suint," occurs to the extent of 20 ozs. per fleece of 9 lbs., and of this quantity about one-third is potash. It is one of the best preventives of rust, and is particularly valuable for use in respect of machinery which is standing. In a refined state it is used in the preparation of "lanolin," and can be

WOOL (*Continued*)—
used for soap-making. (See E. R. Trotman, *Ind. Chem.*, 1927, iii., 195.) In another refined state it is known as wool wax, of sp. gr. 0·94, m.p. 35° C., sap. v. 102, i.v. 25, and ref. ind. 1·48. With respect to the treatment of suint liquors see B. A. Smith and A. T. King (severally) (*Chem. and Ind.*, 1930, **49,** 1057).

Woollen fabrics are liable to attack by certain bacteria, including *B. subtilis* and *B. mesentericus,* causing a swelling of the fibres, loss of natural twist, and later, the loss of tensile strength; they also suffer damage by exposure to actinic light and air.

Emulsions of 90 parts carbon tetrachloride and 90 parts tetrachlorethylene are used industrially under the names of "Hexoran" and "Trioran" for the cleansing of raw wool, as also another tetralin preparation named "Perpentol."

With respect to the bleaching of wool it has been found that when sulphur dioxide and alkali are present in particular proportions they assume a special phase of activity in effect and economy, while the fabrics treated in this way better retain their white bleached appearance even after successive washings. (See Report of Advisory Council, Department of Scientific and Industrial Research for 1929-1930 (H.M. Stationery Office).) High sulphur content means high resistance to deterioration of wool during chemical treatment.

At the Government Wool Disinfection Station at Liverpool, wool is disinfected after some preliminary preparation by a ten minutes' exposure at 102° F. (39° C.) to the action of a dilute alkaline solution in order to remove albuminous matters, followed by further twenty minutes' treatment with a dilute alkaline soap solution at 102° F. (39° C.) to promote a susceptible state of any spores contained in the wool, and subsequently passed through successive baths of a 2 to 3 per cent. solution of formaldehyde, the material being squeezed between rollers at each stage to remove the several liquids. A later illustrated account of this Government Station is given in the *Ind. Chem.*, 1930, vi., 490.

According to S. R. Trotman and R. W. Sutton, scoured wool exposed to air but protected from light is stated to be liable to become acid in reaction and suffer surface damage, so that the loss on subsequent scouring becomes very high. It is found to be infected with a number of bacterial and fungic growths, and has an affinity for dyes differing from that of the undamaged material, the bacterial damage being attributed to damp storage. (See *J. Soc. Dyers and Col.*, 1925, **41,** 121-127.) Sodium silico-fluoride has been found notably efficient as an antiseptic in respect of mildew growths on wool. Other references to the subject of Mildew in Wool Textiles are: R. Burgess and others (*C.T.J.*, 1929, **85,** 193); R. Burgess (*B.C.A.*, 1930, B, 96); and under the heading of "Shirlan."

Wools are graded by feel and diameter of fibre, and there are tests for the various qualities; olive and other oils are ordinarily employed in their preparation and working, the lubrication facilitating the passage of the fibres over each other in combing and carding, in which con-

WOOL (*Continued*)—

nection it is reported that the Textile Department of Leeds University have found a new blend of first-rate lubricant of less costly character.

Descriptions of several so-called "Artificial Wools" include a form of non-continuous artificial silk fibre obtained by the "philanization" of cotton—that is, the production of wool-like effects by the action upon the fibre at 0° C. of concentrated nitric acid. Other makes are known as "VL Yarn" and "N.T." (See also "Sniafil.")

Other References: Effluent from wool-washing factories and its treatment (*C.T.J.*, 1930, **87,** 604); Australian method for clarifying wool-scourers' effluent by chlorine, and incidentally recovering the fat in a purified condition, by J. de Raeve (*C.T.J.*, 1925, **77,** 361); "Constituents of Raw Wool and their Industrial Applications," by E. R. Trotman (*Ind. Chem.*, 1927, iii., 195); Drummond and Baker (*J.S.C.I.*, 1929, **48,** 232 T); H. R. Marston (*B.C.A.*, 1929, B, 227); B. A. Smith on "Treatment and Disposal of Wool-washing Effluent" (*Trans. Inst. Chem., Eng.*, December, 1930, 16); S. R. Trotman (with others) on "Nature of the Proteins of Wool" (*J.S.C.I.*, 1926, **45,** 20 T); J. Barritt on "Literature of Keratin" (*J. Text. Inst.*, 1926, **17,** 111 T); J. Barritt on "The Yield of the Hydrolysed Product Cystine in relation to the Sulphur Content" (*J.S.C.I.*, 1927, **46,** 338 T); J. B. Speakman on "Action of Sodium Sulphide on Wool" (*J.S.C.I.*, 1931, **50,** 1 T); G. F. Pickering on "Wool Grease Distillation" (*J.S.C.I.*, 1925, **44,** 427 T); S. R. and E. R. Trotman on "Experiments on the Chlorination of Wool" (*J.S.C.I.*, 1926, **45,** 111 T); S. R. Trotman on "Damage in Wool" (*Ind. Chem.*, 1928, iv., 118); J. B. Speakman on "Action of Caustic Soda on Wool" (*J.S.C.I.*, 1929, **48,** 321 T); C. P. Bean on "Dyeing of Wool" (*Ind. Chem.*, 1926, ii., 57), and L. L. Lloyd (*Ibid.*, ii., 258); H. Wilkinson on "Light-Fast Colours for Wool" (*Ibid.*, ii., 320); "The Dressing and Dyeing of Wool Rugs" (*Ibid.*, 1927, iii., 78); Report for 1920-1930 of the Council of the British Research Association for the Woollen and Worsted Industries; "Adsorption of Water by Wool," by J. B. Speakman (*J.S.C.I.*, 1930, p. 209 T); "Experiments on the Weighting of Knitted Woollen Goods," by Trotman and Savory (*J.S.C.I.*, 1931, **50,** 299 T); "Unshrinkable Finish of Knitted Woollen Goods," by S. R. Trotman (*J.S.C.I.*, 1931, **50,** 463 T); "Micelle Structure of the Wool Fibre," by J. B. Speakman (*Proc. Roy. Soc.*, 1931, A, **132,** 167); Adeps Lanæ, Degras, and Effluents.

WOOL PITCH—See Pitch.

WOOL WAX—See Waxes.

"WOOLYARNA"—An Italian artificial wool. (See also "Sniafil.")

WORK—Expenditure of energy in overcoming resistance. (See Erg, p. 369.)

WORMSEED OIL (**Chenopodium Oil, Artemisia Oil**)—A yellowish essential oil, ranging in sp. gr. from 0·955 to 0·980 at 25° C., and ref. ind. 1·4723 to 1·4770 at 20° C., some varieties of which are of distinctly unpleasant and others of camphor-like odour. It is distilled from the unexpanded flower-buds of various species of *Artemisia,* including the

WORMSEED OIL (*Continued*)—

Artemisia maritima L. (South Russia and the Levant), *Chenopodium ambrosioides* (U.S.A.), and perhaps *Artemisia annua*, although it has been reported that the botanical source of true wormseed of commerce is *Artemisia cina* (Berg), Willkomm. (See *Pharm. J.*, 1925, **115**, 149-156.)

The American (Maryland) oil is of sp. gr. 0·9302 to 0·9559, is lævorotatory, contains from 25 to 30 per cent. mixed hydrocarbons, including cymene, α-terpinine, etc., and from 60 to 75 per cent. of a repugnant-smelling organic liquid ($C_{10}H_{16}O_2$) named ascaridole, boiling at from 108° to 110° C./15 mm., and constituting the anthelmintic constituent of the oil, which is used for the treatment of the tropical disease named hookworm (ankylostomiasis). (See Henry and Paget (*J.C.S.*, 1925, cxxvii., 1649); Cocking and Hymas (*Analyst*, 1930, **55**, 180); also Santonin.)

The Indian oil is said to have a sp. gr. of from 0·908 to 0·9399 at 15° C.; the Levant oil is said to contain cineol as its chief constituent, and to have a sp. gr. of 0·930; all varieties are soluble in alcohol, ether, etc.

WORMWOOD and WORMWOOD OIL—Wormwood is a very bitter herb (*Artemisia absinthium*) having medicinal value. The oil obtained by distillation of the leaves and from the species *A. glacialis* and *A. mutellina* (0·3 to 0·4 per cent.), used in making absinthe, is of a greenish colour, contains thujone, phellandrene, etc., and is soluble in alcohol and ether; sp. gr. about 0·925 to 0·96; ref. ind. 1·46. The species *A. dracunculus* is used in flavouring the so-called tarragon vinegar. (See Absinthe and Tarragon Oil.)

WORSTED—Woollen yarn, such as socks.

WORT—The liquid product resulting from the mashing of cereal grains (such as barley, rye, and maize, with malt), containing maltose, iso-maltose, dextrine, etc. (See Alcohol, Beer, and Whisky.)

WOULFE'S BOTTLES are glass bottles provided with two or more necks, which can be used as gas generators or as gas-washing bottles. (See Wash Bottles.)

WULFENITE—Crystalline lead molybdate ($PbMoO_4$), of crystal system, No. 2, and sp. gr. 6 to 7, found in some of the U.S.A., etc. (See Molybdenum.)

WURTZITE—A native variety of zinc sulphide found in the form of hexagonal prisms in Montana, Utah, etc.; used in making paints and luminous paint.

X RAYS (**Röntgen Rays**)—A form of ultra-violet light given off from the cathode when passing an electric current of high voltage (in the neighbourhood of 100,000 volts) through a highly vacuous glass tube and deflecting the rays by a mirror. These waves are invisible to the eye; are 10,000 times smaller than those of light (50 to 0·05 millimicrons); cannot be reflected from mirrors or concentrated by use of lens. By their use examination can be made of things 10,000 times finer than with a microscope. They have the power of penetrating solid substances

X RAYS (*Continued*)—

such as animal tissues, paper, wood, and some metals, and by action on a photographic plate behind the object to be radiographed, it is possible to obtain shadowgraphs of portions of the human skeleton, the bones being not so easily penetrated as are the skin, muscle, etc. They have proved of great value in the examination of the structure of ice, graphite, the diamond and other crystals, and the atomic or molecular arrangements of many organic compounds showing, it is said, their dispositions in three dimensions. They are also employed for determining the structure of cellulose, fibres, etc., and find industrial application for the detection of blow-holes and cracks in metals, brazings, and heavy castings; the toughening of varnish on patent leather so that it is made more pliable; the detection of substances by their X-ray spectra; the examination of ferro-concrete, and internal parts of clocks, watches, motor tyres, electric cables, cricket and golf balls, etc. In surgery they are successfully used for locating bullets, etc., in the human body, for indicating the nature of fractures, and distinguishing between strains and dislocations.

The fundamental law of X-ray spectra was discovered by the late H. G. J. Moseley, who also provided the foundation for X-ray analysis.

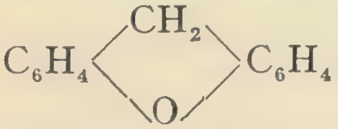
X rays as produced from a mercury-vapour-filled quartz lamp can also be employed for freeing wool and hides from the moth plague, a few minutes' exposure sufficing to kill all pests.

An apparatus designed at the Radiological Research Department at Woolwich serves to penetrate a mass of steel 4 inches in thickness. (See P. W. Priestley (*Ind. Chem.*, 1925, i., 331).)

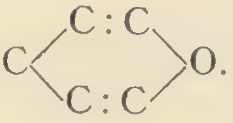
References: "The J Phenomenon and the Compton Effect," by N. M. Bligh (*Chem. and Ind.*, 1926, **45,** 900); applications of X-ray analysis to the identification and determination of the elements, by T. H. Laby (*Trans. Faraday Society*, 1930, **26,** 497); "Application to Chemical Problems," by E. D. Mason (*Chem. and Ind.*, 1932, **51,** 97); F. D. Miles (*Ibid.*, **51,** 142); Bragg and Shearer on "Applications to Chemical Industry" (Lecture, Soc. of Chem. Ind., April 4, 1932); *X Rays and Electrons,* by A. H. Compton (Macmillan and Co., Ltd.); *Rays and X Rays,* by V. E. Pullin (Ernest Benn, Ltd.); *X-Ray Spectroscopy*, by M. Siegbahn (Oxford University Press); Sir W. Bragg, *The Times,* August 21, 1931; also Atoms, Electrons, Radio-activity, Stereochemistry, Ultra-violet Rays, and Wave Lengths.

XANTHATES—Salts of xanthic acid (or ethyl-hydrogen dithiocarbonate $(CS(OC_2H_5)SH)$), such as potassium-ethyl xanthate $(C_2H_5O,CSSK)$.

XANTHENE DYESTUFFS are derivatives of xanthene



$C_6H_4\left\langle\begin{matrix}CH_2\\ O\end{matrix}\right\rangle C_6H_4$ containing the pyrone group



$C\left\langle\begin{matrix}C:C\\ C:C\end{matrix}\right\rangle O$.

XANTHINE $(C_5H_4N_4O_2)$—A white amorphous substance found present in flesh, urine, certain calculi, etc., belonging to the purine group, and nearly allied to uric acid from which it is obtainable by processes of

XANTHINE (*Continued*)—

reduction. There are a number of xanthine bases constituting some principles of plants, including caffeine and theobromine.

XANTHIUM ECHIFATUM seeds are stated to contain 30·7 per cent. kernels, which yield 29·9 per cent. oil, having i.v. 140·8 and sap. v. 190·2, but the press cake contains some toxic principle which renders it harmful to cattle.

XANTHOFFITE—A natural double sulphate of sodium and magnesium found in association with other salts in the potash-bearing districts of Stassfurt, and from which pure sodium sulphide is obtainable.

XANTHOPHYLL—See Chlorophyll and Plant Colouring Matters.

XENON (X)—A very rare element of atomic weight 130·2 (but more recently determined as 131·26(4) ± 0·005): see Whytlaw-Gray, Patterson, and Cawood (*Nature*, 1931, **127,** 970); and sp. gr. 63·5 (gaseous form). It is said to exist in nine isotopic forms, being one of the so-called argon group of gaseous constituents contained in the heavier portion of liquefied air, and is calculated to be present to the extent only of 1 part by volume in 170,000,000 parts. It gives a characteristic spectrum, is less volatile than argon, boils at – 109·1° C. (at which temperature its density is 3·063), and solidifies at – 140° C. It is stated to form a crystalline hydrate under certain specified conditions. Allen and Moore give its m.p. as 111·5 ± 0·5° (*B.C.A.*, 1930, A, 1508).

XEROFORM—Bismuth tri-bromo-phenylate.

X RAYS—See p. 1000.

XYLAN—A pentosan to which K. P. Link gives the formula $(C_5H_8O_4)_n$. Its preparation from wheat straw and its properties have been studied by J. Reilly (with others) (see *B.C.A.*, 1930, A, 1560; *B.C.A.*, 1930, A, 894; and Xylose).

XYLENE (**Xylol**) (C_8H_{10} or $C_6H_4(CH_3)_2$)—A constituent hydrocarbon of the benzene group present in coal naphtha, being a colourless liquid of sp. gr. 8·668, of faint odour distinct from that of benzene, of which it is a homologue. It constitutes a large proportion of so-called "naphtha solvent," and as such is used as a raw material in the manufacture of dyes, also as a wetting and grease-dissolving agent in scouring baths. In point of fact, there are three isomeric xylenes, that from coal tar consisting of a mixture of all three kinds. The ortho-xylene of sp. gr. 0·893 boils at 142°, the meta-xylene of sp. gr. 0·881 at 139°, and the para-xylene of sp. gr. 0·880 at 138° C.; they can be extracted from crude xylol, and are all colourless, mobile liquids, soluble in alcohol and ether. (See Coal and Naphtha.)

XYLENOLS ($C_8H_{10}O$ or $(CH_3)_2C_6H_3,OH$)—Phenolic compounds (dimethylhydroxybenzenes or dimethylphenols) of high boiling-point, of which some six modifications are known, forming part of the constituents of so-called "phenoloids" from blast furnaces, and used in the manufacture of powerful disinfectants.

One of the xylenols is said to be a white, crystalline substance,

XYLENOLS (*Continued*)—
soluble in water and alcohol. (See "Derivatives of *m*-Xylenols," by Rowe (with others) (*J.S.C.I.*, 1931, **50,** 79 T).)

XYLIDINES (Meta, Ortho, and Para)—Liquid amines, used in dyestuffs.

The meta compound ($C_6H_3(CH_3)_2NH_2$) is a colourless oil of sp. gr. 0·9184 and b.p. 215° C.

The ortho compound ($C_6H_3(NH_2)(CH_3)_2$) is a yellow liquid of sp. gr. 0·981 to 0·984 and b.p. about 212° C.

The para compound ($C_6H_3(CH_3)_2NH_2$) can be obtained in white crystalline and oily forms of b.p. 215° C. and sp. gr. 0·980.

All are soluble in alcohol and ether.

(See "Separation of the Constituents of Commercial Xylidine," by G. T. Morgan and W. J. Hickinbottom (*J.S.C.I.*, 1926, **45,** 221 T).)

m-xylidine acetate is an intermediate.

"XYLOLITH"—A building material and flooring composition made from sawdust by the interaction of magnesia and magnesium chloride, producing thereby the magnesium hydroxide in a colloidal form, which cements the mixture; it is made in the forms of slabs and tiles, which are weather-resistant and fireproof. (See Necol, Plastic Wood, and Sorel Cement.)

XYLONITE—See Celluloid.

XYLOSE—A saccharoid stereo-isomeric with arabinose, prepared from such substances as straw and jute by boiling with dilute sulphuric acid. There are methods of preparing this so-called wood sugar from maize cobs to the extent of from 10 to 12 per cent. and from cotton-seed hull bran, which contains from 30 to 35 per cent. pentose. This last-named method is described in the *C.T.J.*, 1930, **86,** 526.

According to W. E. Emley (*Chem. Met. Eng.*, 1930, **37,** 238, and abstract *B.C.A.*, 1930, B, 681), xylose is obtained by hydrolysis with dilute acid of xylan present in cotton-seed hulls (40 per cent.), corn cobs (32 per cent.), pea-nut shells (26 per cent.), and other agricultural wastes, and the method of manufacture is described (see Hall, Slater and Acree, *B.C.A.*, 1930, B, 737). By some it is regarded as the parent substance of lignin (see P. Klason (*B.C.A.*, 1930, A, 1025); also Schrieber (with others) on "The Semi-Commercial Production of Xylose" (*Ind. Eng. Chem.*, 1930, **22,** 497); Maize Oil and Pentoses).

XYLYL—The univalent radical ($CH_3.C_6H_4.CH_2$) derived from xylene.

XYLYLENE—The divalent radical (CH_2,C_6H_4,CH_2) (of ortho, meta, and para forms) derived from xylene.

YACCA GUM—See Gums and Resins, p. 428.

YAJEINE—A crystalline alkaloid from the plant known as "Yaje," seemingly corresponding to *Hæmadictyen Amazonicum* of the Apocynaceæ. It is of toxic character, soluble in chloroform and ether, and is indicated as of the formula $C_{14}H_8N_3O$.

YAM—A genus of plants (*Dioscorea,* N.O. Dioscorëaceæ) natives of W. Indies, Polynesia, China, etc., of which the fleshy roots containing

YAM (*Continued*)—
much starch are used as food after boiling. There are some 150 species, of which varieties are cultivated in Asia, Africa, and America, the *Tamus* (*Testudinaria*) *elephantipes* (a S. African variety) being the so-called Hottentot's Bread.

YEASTS—The yeasts belong to the great family of the fungi. Ordinary cultivated yeast (*Saccharomyces cerevisiæ*) consists of microscopic round or oval vegetable cells of about $\frac{1}{3000}$ inch in diameter, 1 ounce containing about 50,000 million cells. These multiply by gemmation (budding), and are employed in various processes of fermentation—wines, beers and spirits—as also in bread-making. Fermentation induced by yeast can only take place between 3° and 35° C., and the organism is killed by a greater alcoholic strength than represented by a solution of 14 per cent. real alcohol (C_2H_6O). It is independent of the cell walls, and is really due to one of several enzymes (termed zymase) present in their contents, and which can be extracted by disintegration and subjection of the yeast cells to hydraulic pressure. All fermentations effected by living yeast proceed more slowly than when induced by yeast preparations, owing to the changes which take place in grinding the yeast, and most if not all are accelerated by potassium phosphate. It loses its activity when dried and heated to 60° C. or exposed to the action of antiseptics.

The hexoses alone are strictly fermentable by zymase, and of these only four—viz., *d*-glucose, *d*-mannose, *d*-galactose, and *d*-fructose; other sugars, such as maltose and cane sugar, having first of all to be converted into one of these, but certain yeasts which secrete invertase are therefore capable of fermenting cane sugar. Some yeasts secrete both invertase and maltase, which latter can ferment maltose.

There are many varieties of yeast of distinctive properties. *S. cerevisiæ* is the ferment used in beer-making, while the wild yeast, *S. ellipsoideus,* is the wine ferment. There is a certain small amount of fat in the normal yeast cell, which, together with the sterols including ergosterol ($C_{27}H_{42}O$) associated with it, are derived from carbohydrate materials consisting of glycogen and mannan (Daoud and Ling). These are held in combination in the cell, and built up with some complex, which is broken down by acid hydrolysis. Yeast is stated to contain a certain proportion of the B vitamin, while ergosterol is the parent substance of vitamin D.

Industrially, brewers' yeast is prepared from a wort made from barley, rye, maize, and other cereals, in which the conversion of the carbohydrates to maltose has been pushed as far as possible by seeding with a yeast culture. There are a number of modified processes of this sort which give other varieties.

"Aeration yeast" or "air yeast," as now used in this country for bread-making, is prepared under a carefully controlled process of nutrition and aseptic conditions from agar using the right kind of pure culture and aeration of the fermenting mash. (See lecture by J. Vargas Eyre (Inst. of Chem., November, 1931, on the "Fermentation Industries," pp. 12-14).)

YEASTS (*Continued*)—

A number of useful articles are prepared from yeast, including nucleic acid, and a bakelite-like substance named "Ernolith" of plastic character (see "Ernolith"). Dry yeast contains some 50 per cent. proteins, and is a valuable source of vitamins.

Brewery yeast has a considerable food value, and a food named "Marmite" is prepared from it resembling meat extract in flavour.

"Katazymans" is a German food made from yeast by plasmolysis—that is, shrinking of the cells by placing in a hypertonic solution—containing about 66 per cent. sugar carbohydrates and 33 per cent. yeast constituents (*Analyst*, 1926, **51,** 253).

A process is used in Germany for inoculating waste liquors from sugar refineries, distilleries, paper and starch works, with a particular variety of yeast which grows quickly and does not produce alcohol. This increases in quantity at the expense of the carbohydrates in the waste water and added ammonium salts, and is ultimately separated and dried. It is stated that 100 parts of sugar or its equivalent present in the waste, and 37·5 parts of nutritive ammonium salts, yield 150 parts of compressed yeast, which, after drying, contains from 40 to 60 per cent. of albuminous matter. This dried yeast, so rich in nitrogenous matter, is used as cattle fodder, and is reported as fit for human food to replace a large proportion of the necessary albuminoids. (See S. B. Schryver (with others) (*B.C.A.*, 1927, B, 313) on "The Strength of Yeast Cells"; Sobotka and Reiner on "The Selectivity of a Yeast in Respect of Fermentation" (*Biochem. J.*, 1930, **24,** 926); Daoud and Ling (*J.S.C.I.*, 1931, **50,** 379 T); Willimott and Wokes on "Dried Yeast and Yeast Extracts" (*Lancet*, 1928, **215,** 668); also Barm, Enzymes, Ergosterol, Invertase, Marmite, Proteins, Sterols, Vitamins, and Zymase.)

YELLOW WOOD—See Fustic Extract.

YEW (*Taxus*, N.O. Taxaceæ)—A genus of which species are widely distributed. The common yew is *Y. baccata*; the wood is very hard and nearly equal to box for making fine work.

YLANG-YLANG (**Cananga Java Oil**)—A yellow essential oil distilled from the flowers of *Cananga odorata* (indigenous in the Malay Archipelago, and cultivated in the Philippines), of which varieties are known as "cananga" and "manila" oils. They contain methyl and benzyl acetates and benzoates, linalool, geraniol, eugenol, etc. The sp. gr. of ylang-ylang is given as 0·91 to 0·94, ref. ind. 1·494 to 1·505 at 20° C., and opt. rot. $-37°$ to $-45°$ at 20° C., but these constants vary with the source of the oil, which is soluble in alcohol and ether, and is used in perfumery.

YOCCA—A drug from the bark and stems of the Yocca plant of S. Columbia, etc., stated to contain caffeine, and some types of which are used as stimulants.

YOHIMBINE—A crystalline poisonous alkaloid of the empirical formula, $C_{21}H_{26}O_3N_2$, and m.p. 234° to 235° C., extracted from *Corynanthe yohimbe*; used in medicine, and stated to be identical with quebrachine

YOHIMBINE (*Continued*)—

(Raymond Hamet, *Analyst*, 1928, **53**, 500). (See also G. Hahn and W. Brandenberg (*B.C.A.*, 1926, A, 1263; 1927, A, 471); K. Warnat (*Ibid.*, 1926, A, 1263, and 1927, A, 681); P. Karrer and H. Salomon (*Ibid.*, 1927, A, 64); L. Spiegel (*Ibid.*, 1927, A, 163 and 579); and R. Lillig (*B.C.A.*, 1930, B, 485, and A, 1600).) Its preparation is described in a reproduced paper (*C.T.J.*, 1927, **81**, 235).

YOUNG FUSTIC—The heartwood of a sumac (*Rhus cotonus*) used in the leather industry. (See Fustic Extract.)

"YPERITE"—See Mustard Gas.

YTTERBIUM (Yb)—Atomic weight, 173. A very rare element found in the mineral *gadolinite* (*ytterbite*) and associated with yttria. An oxide (Yb_2O_3), a chloride ($YbCl_3$), and a sulphate ($Yb_2(SO_4)_3$) are known. See R. W. Ball on "Separation of Ytterbium by Electrolytic Reduction" (*J. Amer. Chem. Soc.*, 1930, **52**, 4264).

YTTRITE (**Ytterbyte, Gadolinite**)—A mineral containing silicates of yttrium and glucinum, and other rare earths. (See Gadolinite.)

YTTRIUM (Yt) **and its Compounds**—Atomic weight 88·9 with a credited isotope 89; and sp. gr. 3·80. A very rare element found in *fergusonite*, *gadolinite* (*ytterbite*), *xenotimmne*, and *samarskite*, and (like ytterbium), associated with the boron group of elements. It is commonly described as a greyish-black powder which is capable of decomposing water to some slight extent at the ordinary temperatures and more rapidly when heated, forming the oxide Y_2O_3, from which the metal can be obtained by electrolysis. Prepared by electrolysis of the fused chloride mixed with a small quantity of sodium chloride, it is obtainable in coherent form, described by Thompson, Bolton, and Kremers (*B.C.A.*, 1926, p. 489) as bright, lustrous, highly crystalline, and not malleable, d^{15} 4·57 having a m.p. between 1,450° and 1,500° C. It is very soluble in acids, and in addition to the oxide, a number of compounds, mostly reddish-white in colour, are known, including a carbonate ($Y_2(CO_3)_3$), chloride (YCl_3), bromide (YBr_3), iodide (YI_3), nitrate ($Y(NO_3)_3$), sulphate ($Y_2(SO_4)_3$), and acetate ($Y(C_2H_3O_2)_38H_2O$), all of which, excepting the carbonate, are more or less soluble in water. The compounds of yttrium closely resemble the aluminium compounds, and are used in the manufacture of incandescent gas mantles.

YTTROTANTALITE—A rare mineral ($Y_4(Ta_2O_7)_3$), of sp. gr. 3·3. (See Erbium.)

"ZAHN" PROCESS—See Chlorine, p. 185.

ZARATITE (**Emerald Nickel**)—An amorphous, hydrous, basic nickel carbonate ore ($NiCO_3,2Ni(OH)_2,4H_2O$) occurring in Maryland, U.S.A., etc., of sp. gr. 2·5.

"ZAUBERIN"—A German washing material, said to contain 10 per cent. of the sodium salt of para-toluene-sulphochloramide. (See "Aktivin" and "Chloramine T.")

"ZEANIN"—A maize flour, practically free from oil and protein, and preferable to maize grits for brewing, giving a higher yield of extract.

"ZEEMAN EFFECT"—A change (broadening on subdivision into separate lines) affecting the lines of a line spectrum by subjection of the light (as, for example, flame coloured by a chemical compound) to an intense magnetic field.

"ZIERN" CONDENSATION TOWERS—An improved plant for condensation of hydrochloric acid gases. (See *Ind. Chem.*, 1931, vii., 463.)

ZEOLITE PROCESSES (Water Softening)—See Water Softening.

ZEOLITES (**Zeoliths**) are natural mineral deposits of an opaque, vitreous character abundantly diffused in nature, and generally found in amygdaloidal cavities or fissures of basalt and certain crystalline schists, described as double hydrated silicates of aluminium and calcium (or sodium). When treated with acids they partially dissolve, leaving the silica in a gelatinous state. *Stilbite, natrolite,* and *analcime* are three zeolites. For a general review concerning zeolites, their constitution, base exchange, etc., see M. H. Hey (*Min. Mag.*, 1930, **22,** 422). (See also "Doucil," Permutit, and Water Softening.)

ZERO (**Absolute**)—273° C. (See Heat (Notable Temperatures), p. 437.)

ZINC (Zn) **and its Compounds**—Atomic weight 65·38; sp. gr. 6·9; m.p. 419·45° C.; b.p. 918° C.; credited with seven so-called isotopes. Zinc is not met with in nature in the metallic state, but occurs as *calamine* or *zinc spar* (zinc carbonate, $ZnCO_3$) in Silesia, the U.S.A. and Belgium. *Blende* (*sphalerite* or zinc sulphide, ZnS) is found and worked to some extent in England, while in New Jersey (U.S.A.) *zincite,* a red zinc oxide (ZnO), of sp. gr. 5·7 and reported m.p. 1,670 ± 10° (the colour of which is due to manganese), is found in considerable amount. Zinc also occurs in *franklinite* (a compound oxide of zinc and iron), in *gahnite* (*zinc spinnelle,* a zinc aluminate, $ZnOAl_2O_3$), in *smithsonite* as silicate, and other mineral forms. The chief supply of spelter (as zinc is also known) comes from Australian *blende,* and is sufficient to meet all British wants; supplies come also from Canada, but the U.S.A. production is the largest. The world's output is estimated at over 1,400,000 tons *per annum*. (See also Marmatite.)

Zinc is a crystalline metal which can be distilled at 1,040° C.; has a bluish-white appearance, is fairly ductile and malleable, and only tarnishes slightly in moist air. It appears to undergo some allotropic change at 315° C. It is used in making *brass,* forms alloys with tin, copper, and antimony in all proportions, and is a component part of many others containing lead and bismuth. (See Alloys.)

The natural zinc carbonates readily yield the oxide by calcination $ZnCO_3 = ZnO + CO_2$.

In the distillation process of manufacture, the metal is extracted by inter-reaction between carbon, carbon monoxide, and zinc oxide at a temperature above that at which zinc boils, the metal vapour being carried over with the generated gases, and condensed chiefly to the liquid state (at first), but in part in a finely divided state in association

ZINC (*Continued*)—
with zinc oxide as a dust-like powder, known as "zinc dust." (See also Ores, pp. 643-645.)

The electrical process of manufacturing the metal, applicable even to complex and low-grade ores which are not amenable to the distillation process, depends upon the electrolysis of a solution of the sulphate (produced by dissolving the metal out of the roasted ore by sulphuric acid). In this process, electrodes of lead and aluminium are used, the zinc being deposited on the cathode (aluminium pole), and subsequently stripped off and melted into ingots of 99·95 per cent. purity.

Electrolytic zinc extraction is conducted on a large scale in Tasmania, U.S.A., and Canada, and is the subject of an article by W. E. Harris (*Ind. Chem.*, 1927, iii., 27). A plant for the electrolytic extraction of zinc from Joplin ores is described by Tainton and Bosqui (*B.C.A.*, 1930, B, 718).

The production of zinc and chlorine from fused zinc chloride is referred to under the heading of Zinc Chloride.

Sulphuric acid is made (chiefly by the "contact" process) in connection with zinc-blende calcination as conducted with the object of obtaining the oxide ($ZnS + 3O = ZnO + SO_2$), and the subject of zinc-blende roasting is dealt with in the report of a general discussion on the subjects of combustion of sulphur-containing materials and mechanical furnaces (*C.T.J.*, 1925, **76,** 459); see also P. Parrish (*C.T.J.*, 1925, **76,** pp. 481 and 509), and article on "Copper Refining and Zinc Smelting" (*Ind. Chem.*, 1925, i., 425).

A new continuous process (Coley's) is stated to yield complete extraction of the metal from even low-grade ores at 300° C. at a lower temperature than ordinarily employed—viz., 1,000° to 1,100° C. instead of about 1,400° C.—and at a lower cost. This process eliminates the use of solid coal and appears to be based upon the use of heavy hydrocarbon oil under conditions so arranged that the oil is brought into contact with the heated zinc oxide, carbon being liberated (by the cracking process) in an active chemical form, and reduction effected very completely. Further details are given in *Ind. Chem.*, 1926, ii., 494, and 1930, vi., 357; by O. W. Roskill (*Ind. Chem.*, 1931, vii., 449); and *Chem. and Ind.*, 1928, **47,** 43. (See also Ores.)

The British Engineering Standards Association have published standards for different qualities of zinc—viz., fine zinc (or spelter), grade A (99·95 per cent.), B (99·90 per cent.), special zinc (99·50 per cent.), and foundry zinc (98·50 per cent.).

A "spectroscopically" pure zinc is produced by the New Jersey Zinc Company (U.S.A.), of unusual softness, purity 99·9999 per cent., m.p. 419·45, and exhibiting a tensile strength of 14,000 lbs. per square inch. (See H. M. Cyr, *B.C.A.*, 1927, B, 390.)

Zinc dust is used in many chemical and metallurgical industries, and varies in composition according to the process of manufacture, different samples showing a content of very finely divided zinc varying from 31·2 to 89 per cent., the other chief constituent being oxide of zinc associated with a number of other impurities. On average it contains

ZINC (*Continued*)—

about 85 per cent. zinc and 15 per cent. oxide, and has a sp. gr. of 6·896, a cubic foot weighing about 200 lbs.

The metal is extensively used for roofing, as a lining for packing cases, and for galvanizing (coating) iron to which it gives durability by preserving it from atmospheric oxidation, although cadmium has largely superseded zinc in plating practice in the U.S.A. (See W. L. Patterson on "Zinc Corrosion" (*J.S.C.I.*, 1926, **45,** 323 T, and 1927, **46,** 390 T); also Galvanizing.)

It is also largely used in the dyestuffs industry—for example, in the reduction of nitro-compounds to inorganic amines, and in the preparation of sodium hydrosulphite for use in the reduction of vat colours. Again, it finds employment for the precipitation of various other metals from their solutions, and as it possesses the property of combining with dry nitrogen only at a high temperature, and of giving with moist air a basic carbonate, or with sea-water an oxychloride (which protects the bulk of metal from further alteration), it is used for the painting of iron objects and galvanization by Sherard's method of cementation. (See J. N. Friend on "Zinc for Electric Batteries" (*C.T.J.*, 1929, **84,** 514) and Metals (Sherardizing).)

Zinc Oxide (ZnO) is produced as a soft white powder when the metal is burned in the air; it is insoluble in water, and is used in medicine, in glass-making, preparing lubricating greases, ceramics, and as a pigment, having the advantage of not being blackened by exposure to the air when sulphuretted hydrogen is contained therein. Its incorporation in iron-oxide paints is stated to greatly improve their quality and lasting properties. It is also used in the rubber industry; for incorporation in the tread of motor tyres to improve their wear; by boiler-makers as a preventive of internal corrosion, and in conjunction with oil as a lubricant which prevents corrosion in bearings.

The largest production of zinc oxide comes from the U.S.A., the bulk of which is made directly from the ores (*franklinite* and *zincite*), of which large deposits occur at New Jersey, whereas the English make is either from *calamine* or spelter. (See "The Zinc Oxide Industry," by N. F. Budgen (*C.T.J.*, 1925, **76,** 227), D. R. Johnstone (*Ind. Chem.*, 1927, iii., 245), and R. G. Daniels (*B.C.A.*, 1928, B, 783).

The hydroxide ($Zn(HO)_2$), which is produced in a white flocculent form when an alkaline hydroxide is added to a solution of a zinc salt, is soluble in an excess of alkali, and can be obtained in crystalline form.

Zinc Acetate ($Zn(C_2H_3O_2)_2.3H_2O$) is a white crystalline salt, soluble in water, and used as a mordant in dyeing.

Zinc-Ammonium Chloride ($ZnCl_2.5NH_3.H_2O$) is a white powder used in welding and as a soldering flux.

Zinc Chloride ($ZnCl_2$) is prepared by dissolving the metal in hydrochloric acid and concentrating to that state in which it solidifies upon cooling, when it is cast into sticks. It is a deliquescent soft compound, m.p. 262° C., b.p. 730° C., very soluble in water, and can be distilled without decomposition. Commercially it is also prepared in the form

ZINC (*Continued*)—

of a strong solution of 102° Tw., and used as an antiseptic cotton-sizing ingredient and otherwise in the textile industries, also in connection with soldering and as a wood preservative. It can be prepared in anhydrous form by action of chlorine upon metallic zinc at 500° C.; also by passing phosgene or a mixture of carbon monoxide and chlorine into a mixture of zinc oxide-containing material and molten zinc chloride at 400° C. (*C.T.J.*, 1931, **89**, 555). A paste consisting of a mixture of the chloride with zinc oxide is employed in dentistry, under the name of "oxychloride," as a stopping for teeth. (See "The Electrolysis of Molten Zinc Chloride," by R. Threlfall (*J.S.C.I.*, 1928, **48**, 210 T), and Sorel Cement.)

Zinc Oxychlorides—See H. C. Holland (*J.C.S.*, 1930, p. 643).

Zinc Chromate ($ZnCrO_4,7H_2O$) is a yellow crystalline substance, insoluble in water, and finds increasing use as a pigment and catalyst. It is made by action of chromic acid on zinc hydroxide, and commercially in a basic form by dissolving zinc oxide in sulphuric acid and precipitation with an excess of sodium dichromate at about 50° C. (See "Zinc Yellows.")

Zinc Dichromate ($ZnCr_2O_7$) is an orange-coloured substance, insoluble in water, and used as a pigment.

Zinc Fluoride (ZnF_2) is a white powder, insoluble in water, used in the ceramic industries.

Zinc Iodide (ZnI_2) can be prepared by the interaction of zinc sulphate and barium iodide, the resulting solution being afterwards evaporated and crystallized. For process work, it is prepared also by the direct action of iodine upon metallic zinc and dissolving the product in water.

Zinc Nitrate ($Zn(NO_3)_2.6H_2O$) is a white crystalline salt, soluble in water, and used to some extent in medicine.

Zinc Sulphate is manufactured by roasting the mineral sulphide in air under certain careful conditions and dissolving out the sulphate thus produced; also by dissolving the metal in dilute sulphuric acid. It crystallizes in monoclinic form as $ZnSO_4,7H_2O$, is very soluble in water, and somewhat efflorescent. The monohydrate ($ZnSO_4,H_2O$) becomes anhydrous upon heating to about 300° C., and is decomposed at a higher temperature into sulphur dioxide, oxygen, and zinc oxide. It is a particularly poisonous salt, and finds use in medical practice as an antiseptic, also as an astringent preservative agent for wood and skins, as a mordant in calico-printing, and as a weed-killer. It has been stated that more than 21 per cent. of the world's production of zinc is at present made by the electrolysis of zinc sulphate.

Zinc Sulphite ($ZnSO_3 2H_2O$)—A white crystalline powder made by the action of sulphurous acid on zinc hydroxide; used as an anatomical preservative and in sugar refining as a decolourizing agent.

Zinc Sulphide (ZnS) is found in native form as *wurtzite*. When precipitated from a solution of a zinc salt by addition of an alkaline

ZINC (*Continued*)—

sulphide solution or passage of gaseous hydrogen sulphide, it is a practically white amorphous substance insoluble in water and acetic acid, and is used to some extent as a luminous agent, also as a pigment in place of white-lead. If prepared of chemical purity the sulphide is stated to exhibit little or no phosphorescence, but the introduction of a very minute quantity of copper or manganese chloride or some other heavy metallic salts produces a fine glow; when it contains as little as 0·00006 gramme copper and is heated to redness it exhibits a beautiful phosphorescence. The preparation of the activating mixture and the phosphorescent product is described by R. Rhode (*C.T.J.*, 1930, **86,** 502, and *Chemiker-Ztg.*, May 14, 1930, p. 369).

A mixture of the sulphide containing 1 to 30 per cent. cadmium sulphide is stated to exhibit a much greater luminescence under X rays than ordinary zinc sulphide. (See J. Einig (*B.C.A.*, 1931, B, 308, and *C.T.J.*, 1932, **90,** 283), and Paints.)

Irradiated by bombardment with alpha rays from radium, zinc sulphide crystals are used to coat the faces of watches and compass cards, so that they are visible in the dark. Phosphorescent zinc sulphide is obtained as a white spongy mass of wurtzite crystals when an intimate mixture of finely pulverized zinc and sulphur is exploded by shock, heat, or friction (Constal and Prevet, *B.C.A.*, 1929, B, 524).

Zinc Carbonate ($ZnCO_3$) in dry form is a white amorphous powder, insoluble in water, and used as a pigment and in medicine, whereas *Zinci carbonas* of the Pharmacopœia is a basic compound having the composition expressed by $ZnCO_3,2Zn(HO)_2,H_2O$.

Zinc Cyanide ($Zn(CN)_2$)—A white poisonous powder, insoluble in water, but soluble in dilute mineral acids, made by precipitation from a soluble zinc salt with potassium cyanide solution; used medicinally.

Zinc Ethyl ($Zn(C_2H_5)_2$)—A colourless liquid of sp. gr. 1·18, and b.p. 118° C., which fires upon exposure to the air, prepared by interaction between ethyl iodide, zinc, and sodium-zinc.

All the soluble salts of zinc are poisonous.

(See N. F. Budgen on "Recovery of Valuable Materials from Galvanizers By-products" (*Ind. Chem.*, 1927, iii., 55); W. S. Patterson on "The Outdoor Corrosion of Zinc" (*J.S.C.I.*, 1931, **50,** 120 T); zinc meta-arsenite as a wood preservative (*Ind. Chem.*, 1931, vii., 293).)

ZINCATES—Compounds such as potassium zincate (K_2ZnO_2)—made by dissolving zinc or zinc hydroxide in a solution of potassium hydroxide.

ZINC BLENDE—See Zinc and Sulphur.

ZINC-COPPER COUPLE—See Copper-Zinc Couple.

"ZINC DUST" (ordinary commercial) is a fine grey powder (90 to 92 per cent.) susceptible of rapid oxidation and firing; in great request in dyeworks as a reducing agent. One grade consists of 40 per cent. zinc, 2½ per cent. lead, 4 per cent. cadmium, 50 per cent. zinc oxide, and 3½ per cent. zinc carbonate. (See Zinc, p. 1008.)

"ZINC FORMOSUL" is described as basic zinc formaldehyde-sulphoxylate, being a greyish-white powder, insoluble in water, but which exercises reducing power when boiled with very dilute acids, or at high temperatures in their absence. It can be used in the autoclave and Twitchell processes of fat splitting, and is stated to assist in the bleaching of the resulting glycerol. (See Hydrosulphites.)

"ZINC WHITE"—Zinc (oxide) of various degrees of purity. (See also Paints (Orr's Zinc White).)

"ZINC YELLOWS"—Mixtures of basic chromates of zinc and potassium. (See W. Ludwig, *B.C.A.*, 1932, B, 71.)

ZINGERONE—See Ginger.

"ZINNATINE"—The name given to what is described as a non-poisonous acid-resisting gold coating for the insides of food containers and closures capable of resisting all blackening stains.

ZIRCONIUM (Zr) **and its Compounds**—Atomic weight 91·2; sp. gr. variously given between 4·15 and 6·4; m.p. variously given 1,600° to 1,850° C. As obtained by reduction from its oxide ores, it is a black amorphous powder, and when agglomerated by fusion it presents a steel-grey appearance. It is said to have three or four isotopic forms, and can be obtained both from zirconium chloride and potassium-zirconium fluoride by action of metallic sodium. According to A. E. van Arkel and J. H. de Boer (*J.S.C.I.*, 1925, **44**, B, 994) it can be obtained in pure form by passing the vapour of the iodide over a heated tungsten filament, as a thick layer thereon. It can also be deposited on zinc when that metal is placed in a methyl-alcoholic solution of zirconium sulphate (H. S. Gable, *J. Amer. C.S.*, 1930, **52**, 3741). Other processes of production, including that of the commercial zirconium by the alumino-thermic method, are described by J. F. Corrigan (*Ind. Chem.*, 1931, vii., 97).

It forms alloys with copper, gold, and nickel at high temperatures, and a silvery white, crystalline alloy of zirconium with aluminium has been prepared of the composition Zr_3Al_4. It belongs to the same group of elements as titanium, is a good conductor of electricity, fairly soft and ductile when pure, and does not easily tarnish in the air unless heated, when it oxidizes slowly. It is almost free from attack by acids, excepting aqua regia and hydrofluoric acid, and when heated to redness, combines readily with chlorine, nitrogen, and oxygen.

During the Great War, zirconium in small amount (0·34 per cent.) was introduced into the steel used by the French in making armour-plate, as in association with 3 per cent. of nickel it was found to add to its tensile strength. It is also used as a constituent of the alloy named "Cooperite."

It has a greater affinity for oxygen than silicon presents at high temperatures, and for this reason a greatly increased recovery of silicon in finished steel is obtained by its use, while at the same time it is efficient in removing the final traces of oxygen and nitrogen from the steel. The zirconium is oxidized, and together with the oxides of silicon and manganese is completely removed as fusible slag.

ZIRCONIUM (*Continued*)—

Zirconium occurs in so-called zircons—that is, silicate ($ZrSiO_4$)—in Norway, Ceylon, and Madagascar, while as oxide (ZrO_2) it is found in Brazil and Ceylon as *brazilite* or *baddeleyite* (a mineral of crystal system, No. 5, and sp. gr. 5 to 6) containing about 96·5 per cent. ZrO_2; it is also found in association with other metals in various *columbates*. Another Brazilian deposit, known as *orvillite*, is said to contain about 72 per cent. ZrO_2. *Zirkite* is light grey to black in colour, and varies in sp. gr. from 4·8 to 5·2; it is stated to be a mixture of *brazilite, zircon*, and another silicate of zirconium.

Both *brazilite* and *zirkite* are employed as refractories in the compounding of zirkite bricks and cements, after freeing them from the associated oxides of iron, aluminium, and titanium by boiling in hydrochloric or sulphuric acid.

Zirconium salts are very basic in character, and in solution have a tendency to undergo hydrolysis, and to pass into a more or less colloidal state.

Zirconium Oxide (Zirconia ZrO_2), stated to exist in three polymorphic forms, is obtained by heating the hydroxide $Zr(OH)_4$, is stated to have a m.p. of 2,900° C., and is a heavy, insoluble, white, amorphous powder of sp. gr. 5·0. A method of production from semi-refined ores is described in a paper by K. Tabata and S. Moriyasa (*B.C.A.*, 1926, B, 1011). Apart from its value as a refractory material, it can be used (although this use has been practically superseded by thoria) in the preparation of incandescent gas mantles; also as an abrasive in ceramics, and in the compounding of acid-proof utensils and enamels. (See Refractories.)

Zirconia crucibles have been used to melt pure iron, platinum, and tungsten alloys, and zirconia linings for the hearths of steel furnaces are very durable.

Zirconia has a very low coefficient of thermal expansion, and is used in the making of special qualities of glass, its employment, among other properties, enhancing resistance of glass to attack by alkaline solutions.

Zirconium Acetate ($Zr(C_2H_3O_2)_3OH$) is a white, crystalline, soluble salt, used for weighting silk.

Zirconium Carbide (ZrC_2) decomposes water and finds use as an abrasive.

Zirconium Carbonate (basic) ($3ZrO_2CO_2.6H_2O$) is a white insoluble compound prepared by interaction of a soluble zirconium salt and a solution of sodium carbonate, from which the oxide can be made.

Zirconium Hydroxide ($Zr(OH)_4$) is a white, bulky compound, insoluble in water, prepared by precipitation from a soluble zirconium salt, using a solution of sodium hydroxide.

There are several nitrates, including the normal salt ($Zr(NO_3)_4.5H_2O$), and a sulphate ($Zr(SO_4)_2.4H_2O$)—crystalline compounds soluble in water; a chloride ($ZrCl_4$), which is decomposed by water but is soluble in alcohol, and a number of other compounds bearing a resemblance to those of thorium and silicon. The preparation of the tetrachloride and

ZIRCONIUM (*Continued*)—

determination of its vapour density is the subject of a paper by Friend, Colley, and Hayes (*J.C.S.*, 1930, p. 494).

(See also an American article on "Zirconium and its Compounds," by F. C. Nonamaker (*C.T.J.*, August 29, 1924); J. H. de Boer (*B.C.A.*, 1927, B, 941); J. F. Corrigan on "The Economic Significance of Zirconium and its Compounds" (*Ind. Chem.*, 1931, vii., 97); *Zirconium*, by Venable: a monograph of the Amer. Chem. Soc. (Chem. Catalog. Co., Inc., N.Y.); also Hafnium.)

ZIRCONS—These mineral zirconium silicates occur in nature of various colours—white (in Brazil), reddish-brown (in Norway), grey (in Norway and Madagascar), brown (in Greenland), etc.—and in all, or nearly all of them, there is a hafnium content in the form of HfO_2. All zircons exhibit radio-active properties. (See Hafnium, and Zirconium, p. 1013.)

ZIRKITE—See Zirconium.

"ZOLLPEER" CAR POWER—The name given to an electrically produced form of carbon at a temperature of over 7,000° F. ground down very finely and submitted to later treatment whereby the particles are reduced to the alleged size of 75 millimicrons (one millimicron being equal to ·000,001 millimetre), incorporated to the extent of less than 5 per cent. with other solidifying ingredients such as naphthaline and oil. A liquid form of the same active principle (the carbon) is described under the heading of "Autrosol."

"ZONOLITE"—The trade name of an industrial mineral manufactured from *vermiculite* (a ferrous-aluminous magnesium silicate) by dispersion of its water content by means of heat. It is stated to have insulating value equal to that of cork and to withstand temperatures up to 2,500° F. without fusing, thus qualifying it also for use in the construction of ovens and kilns.

"ZULITE"—A proprietary wood preservative made from an oil produced in the manufacture of Mond tar, and stated to be a good preventive against "rot," white-ant attacks in the tropics, and the ravages of the *Teredo navalis*, or marine boring-worm.

ZYMASE—An enzyme contained in the cells of yeast. Sometimes the plural term zymases is used, as meaning the same thing as enzymes, but that should be avoided. (See Invertase and Yeasts.)

ZYMIN—A medical preparation of enzymic character extracted from moist yeast by digestion in acetone, separating the undissolved matter, kneading it with ether, filtering, and drying the remaining substance at 45° C. It is more active than yeast extract in producing fermentation.

ZYMOGENS—Progenitor inactive substances from which, it is conjectured, enzymes are formed in the organism (cells)—*e.g.*, pepsin from pepsinogen and trypsin from trypsinogen.

Printed in Great Britain for
Baillière, Tindall and Cox, by Billing and Sons, Ltd., Guildford and Esher.

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